

CHAPTER 41

SAFETY REQUIREMENTS FOR THE USE OF
RADIATION MACHINES AND CERTAIN USES
OF RADIOACTIVE MATERIALS**641—41.1(136C) X-rays in the healing arts.**

41.1(1) Scope. This rule establishes requirements, for which a registrant is responsible, for use of X-ray equipment by or under the supervision of an individual authorized by and licensed in accordance with state statutes to engage in the healing arts or veterinary medicine. The provisions of this rule are in addition to, and not in substitution for, any other applicable provisions of these rules. The provisions of Chapter 41 are in addition to, and not in substitution for any other applicable portions of 641—Chapters 38 to 42. All references to any Code of Federal Regulations (CFR) in this chapter are those in effect as of July 1, 1998.

41.1(2) Definitions. For the purpose of this chapter, the definitions of 641—Chapter 38 may also apply. The following are specific to rule 41.1(136C).

“*Accessible surface*” means the external surface of the enclosure or housing of the radiation producing machine as provided by the manufacturer.

“*Added filtration*” means any filtration which is in addition to the inherent filtration.

“*Aluminum equivalent*” means the thickness of type 1100 aluminum alloy affording the same attenuation, under specified conditions, as the material in question.

“*Attenuation block*” means a block or stack, having dimensions 20 centimeters by 20 centimeters by 3.8 centimeters, of type 1100 aluminum alloy or other materials having equivalent attenuation.

“*Automatic exposure control (AEC)*” means a device which automatically controls one or more technique factors in order to obtain at a preselected location(s) a required quantity of radiation (see also “Phototimer”). (Includes devices such as phototimers and ion chambers.)

“*Barrier*” (see “Protective barrier”).

“*Beam-limiting device*” means a device which provides a means to restrict the dimensions of the X-ray field.

“*Beam monitoring system*” means a system designed to detect and measure the radiation present in the useful beam.

“*C-arm X-ray system*” means an X-ray system in which the image receptor and X-ray tube housing assembly are connected by a common mechanical support system in order to maintain a desired spatial relationship. This system is designed to allow a change in the projection of the beam through the patient without a change in the position of the patient.

“*Cephalometric device*” means a device intended for the radiographic visualization and measurement of the dimensions of the human head.

“*Certified components*” means components of X-ray systems which are subject to regulations promulgated under Public Law 90-602, the “Radiation Control for Health and Safety Act of 1968,” the Food and Drug Administration.

“*Certified system*” means any X-ray system which has one or more certified component(s).

“Coefficient of variation” or “C” means the ratio of the standard deviation to the mean value of a population of observations. It is estimated using the following equation:

$$C = \frac{s}{\bar{x}} = \frac{1}{\bar{x}} \left[\sum_{i=1}^n \frac{(x_i - \bar{x})^2}{n-1} \right]^{1/2}$$

where:

- \underline{s} = Estimated standard deviation of the population.
- \bar{X} = Mean value of observations in sample.
- X_i = i^{th} observation in sample.
- n = Number of observations in sample.

“Computed tomography” means the production of a tomogram by the acquisition and computer processing of X-ray transmission data.

“Control panel” (see X-ray control panel).

“Cooling curve” means the graphical relationship between heat units stored and cooling time.

“CT” (see “Computed tomography”).

“Dead-man switch” means a switch so constructed that a circuit closing contact can be maintained only by continuous pressure on the switch by the operator.

“Detector” (see “Radiation detector”).

“Diagnostic source assembly” means the tube housing assembly with a beam-limiting device attached.

“Direct scattered radiation” means that scattered radiation which has been deviated in direction only by materials irradiated by the useful beam (see “Scattered radiation”).

“Entrance exposure rate” means the exposure free in air per unit time at the point where the center of the useful beam enters the patient.

“Equipment” (see “X-ray equipment”).

“Field emission equipment” means equipment which uses an X-ray tube in which electron emission from the cathode is due solely to the action of an electric field.

“Filter” means material placed in the useful beam to preferentially absorb selected radiations.

“Fluoroscopic imaging assembly” means a subsystem in which X-ray photons produce a visual image. It includes the image receptor(s) such as the image intensifier and spot-film device, electrical interlocks, if any, and structural material providing linkage between the image receptor and diagnostic source assembly.

“Focal spot (actual)” means the area projected on the anode of the X-ray tube bombarded by the electrons accelerated from the cathode and from which the useful beam originates.

“General purpose radiographic X-ray system” means any radiographic X-ray system which, by design, is not limited to radiographic examination of specific anatomical regions.

“Gonad shield” means a protective barrier for the testes or ovaries.

“Healing arts screening” means the testing of human beings using X-ray machines for the detection or evaluation of health indications when such tests are not specifically and individually ordered by a licensed practitioner of the healing arts legally authorized to prescribe such X-ray tests for the purpose of diagnosis or treatment.

“Heat unit” means a unit of energy equal to the product of the peak kilovoltage, milliamperes, and seconds, i.e., $kVp \times mA \times \text{second}$.

“Image intensifier” means a device, installed in its housing, which instantaneously converts an X-ray pattern into a corresponding light image of higher energy intensity.

“*Image receptor*” means any device, such as a fluorescent screen or radiographic film, which transforms incident X-ray photons either into a visible image or into another form which can be made into a visible image by further transformations.

“*Inherent filtration*” means the filtration of the useful beam provided by the permanently installed components of the tube housing assembly.

“*Kilovolts peak*” (see “Peak tube potential”).

“*kV*” means kilovolts.

“*kVp*” (see “Peak tube potential”).

“*kWs*” means kilowatt second.

“*Lead equivalent*” means the thickness of lead affording the same attenuation, under specified conditions, as the material in question.

“*Leakage radiation*” means radiation emanating from the diagnostic or therapeutic source assembly except for:

- a. The useful beam, and
- b. Radiation produced when the exposure switch or timer is not activated.

“*Leakage technique factors*” means the technique factors associated with the diagnostic or therapeutic source assembly which are used in measuring leakage radiation. They are defined as follows:

- a. For diagnostic source assemblies intended for capacitor energy storage equipment, the maximum-rated peak tube potential and the maximum-rated number of exposures in an hour for operation at the maximum-rated peak tube potential with the quantity of charge per exposure being 10 millicoulombs, i.e., 10 milliamperere seconds, or the minimum obtainable from the unit, whichever is larger.
- b. For diagnostic source assemblies intended for field emission equipment rated for pulsed operation, the maximum-rated peak tube potential and the maximum-rated number of X-ray pulses in an hour for operation at the maximum-rated peak tube potential.
- c. For all other diagnostic or therapeutic source assemblies, the maximum-rated peak tube potential and the maximum-rated continuous tube current for the maximum-rated peak tube potential.

“*Light field*” means that area of the intersection of the light beam from the beam-limiting device and one of the set of planes parallel to and including the plane of the image receptor, whose perimeter is the locus of points at which the illumination is one-fourth of the maximum in the intersection.

“*Linear attenuation coefficient*” or “ μ ” means the quotient of dN/N divided by dl when dN/N is the fraction of uncharged ionizing radiation that experience interactions in traversing a distance dl in a specified material.

“*Line-voltage regulation*” means the difference between the no-load and the load line potentials expressed as a percent of the load line potential. It is calculated using the following equation:

$$\text{Percent line-voltage regulation} = 100 (V_n - V_l) / V_l$$

where

V_n = No-load line potential and

V_l = Load line potential.

“*mA*” means milliamperere.

“*mAs*” means milliamperere second.

“*Maximum line current*” means the root-mean-square current in the supply line of an X-ray machine operating at its maximum rating.

“*Mobile X-ray equipment*” (see “X-ray equipment”).

“*PBL*” (see “Positive beam limitation”).

“*Phototimer*” means a method for controlling radiation exposures to image receptors by the amount of radiation which reaches a radiation-monitoring device(s). The radiation-monitoring device(s) is part of an electronic circuit which controls the duration of time the tube is activated (see “Automatic exposure control”).

“*PID*” (see “Position indicating device”).

“*Portable X-ray equipment*” (see “X-ray equipment”).

“*Position indicating device*” means a device on dental X-ray equipment used to indicate the beam position and to establish a definite source-surface (skin) distance. It may or may not incorporate or serve as a beam-limiting device.

“*Positive beam limitation*” means the automatic or semiautomatic adjustment of an X-ray beam to the size of the selected image receptor, whereby exposures cannot be made without such adjustment.

“*Primary protective barrier*” (see “Protective barrier”).

“*Protective apron*” means an apron made of radiation-absorbing materials used to reduce radiation exposure.

“*Protective barrier*” means a barrier of radiation-absorbing material(s) used to reduce radiation exposure. The types of protective barriers are as follows:

a. “*Primary protective barrier*” means the material, excluding filters, placed in the useful beam, for protection purposes, to reduce the radiation exposure.

b. “*Secondary protective barrier*” means a barrier sufficient to attenuate the stray radiation to the required degree.

“*Protective glove*” means a glove made of radiation-absorbing materials used to reduce radiation exposure.

“*Radiation detector*” means a device which, in the presence of radiation, provides a signal or other indication suitable for use in measuring one or more quantities of incident radiation.

“*Radiation therapy simulation system*” means a radiographic or fluoroscopic X-ray system intended for localizing the volume to be exposed during radiation therapy and confirming the position and size of the therapeutic irradiation field.

“*Radiograph*” means an image receptor on which the image is created directly or indirectly by an X-ray pattern and results in a permanent record.

“*Rating*” means the operating limits as specified by the component manufacturer.

“*Recording*” means producing a permanent form of an image resulting from X-ray photons.

“*Response time*” means the time required for an instrument system to reach 90 percent of its final reading when the radiation-sensitive volume of the instrument system is exposed to a step change in radiation flux from zero sufficient to provide a steady state midscale reading.

“*Secondary protective barrier*” (see “Protective barrier”).

“*Shutter*” means a device attached to the tube housing assembly which can intercept the entire cross-sectional area of the useful beam and which has a lead equivalency not less than that of the tube housing assembly.

“*SID*” (see “Source-image receptor distance”).

“*Source*” means the focal spot of the X-ray tube.

“*Source-image receptor distance*” means the distance from the source to the center of the input surface of the image receptor.

“*Spot check*” means a procedure which is performed to ensure that a previous calibration continues to be valid.

“*Spot film*” means a radiograph which is made during a fluoroscopic examination to permanently record conditions which exist during that fluoroscopic procedure.

“*Spot-film device*” means a device intended to transport or position a radiographic image receptor between the X-ray source and fluoroscopic image receptor. It includes a device intended to hold a cassette over the input end of an image intensifier for the purpose of making a radiograph.

“SSD” means the distance between the source and the skin entrance plane of the patient.

“Stationary X-ray equipment” (see “X-ray equipment”).

“Stray radiation” means the sum of leakage and scattered radiation.

“Technique factors” means the following conditions of operation:

a. For capacitor energy storage equipment, peak tube potential in kV and quantity of charge in mAs;

b. For field emission equipment rated for pulsed operation, peak tube potential in kV, and number of X-ray pulses;

c. For CT X-ray systems designed for pulsed operation, peak tube potential in kV, scan time in seconds, and either tube current in mA, X-ray pulse width in seconds, and the number of X-ray pulses per scan, or the product of tube current, X-ray pulse width, and the number of X-ray pulses in mAs;

d. For CT X-ray systems not designed for pulsed operation, peak tube potential in kV, and either tube current in mA and scan time in seconds, or the product of tube current and exposure time in mAs and the scan time when the scan time and exposure time are equivalent; and

e. For all other equipment, peak tube potential in kV, and either tube current in mA and exposure time in seconds, or the product of tube current and exposure time in mAs.

“Termination of irradiation” means the stopping of irradiation in a fashion which will not permit continuance of irradiation without the resetting of operating conditions at the control panel.

“Tomogram” means the depiction of the X-ray attenuation properties of a section through the body.

“Tube housing assembly” means the tube housing with tube installed. It includes high-voltage, or filament transformers, or both, and other appropriate elements when such are contained within the tube housing.

“Tube rating chart” means the set of curves which specify the rated limits of operation of the tube in terms of the technique factors.

“Useful beam” means the radiation emanating from the tube housing port or the radiation head and passing through the aperture of the beam-limiting device when the exposure controls are in a mode to cause the system to produce radiation.

“Variable-aperture beam-limiting device” means a beam-limiting device which has capacity for stepless adjustment of the X-ray field size at a given SID.

“Visible area” means that portion of the input surface of the image receptor over which incident X-ray photons are producing a visible image.

“X-ray control” means a device, switch, button or similar means by which an operator initiates or terminates the radiation exposure. The X-ray exposure control may include such associated equipment as timers and backup timers.

“X-ray control panel” means a device which controls input power to the X-ray high-voltage generator and the X-ray tube. It includes equipment such as timers, phototimers, automatic brightness stabilizers, and similar devices, which control the technique factors of an X-ray exposure.

“X-ray equipment” means an X-ray system, subsystem, or component thereof. Types of X-ray equipment are as follows:

a. “Mobile X-ray equipment” means X-ray equipment mounted on a permanent base with wheels or casters for moving while completely assembled.

b. “Portable X-ray equipment” means X-ray equipment designed to be hand-carried.

c. “Stationary X-ray equipment” means X-ray equipment which is installed in a fixed location.

“X-ray field” means that area of the intersection of the useful beam and any one of the set of planes parallel to and including the plane of the image receptor, whose perimeter is the locus of points at which the exposure rate is one-fourth of the maximum in the intersection.

“X-ray high-voltage generator” means a device which transforms electrical energy from the potential supplied by the X-ray control to the tube operating potential. The device may also include means for transforming alternating current to direct current, filament transformers for the X-ray tube(s), high-voltage switches, electrical protective devices, and other appropriate elements.

“X-ray system” means an assemblage of components for the controlled production of X-rays. It includes minimally an X-ray high-voltage generator, an X-ray control, a tube housing assembly, a beam-limiting device, and the necessary supporting structures. Additional components which function with the system are considered integral parts of the system.

“X-ray table” means a patient support device with its patient support structure (tabletop) interposed between the patient and the image receptor during radiography or fluoroscopy. This includes, but is not limited to, any stretcher equipped with a radiolucent panel and any table equipped with a cassette tray (or bucky), cassette tunnel, image intensifier, or spot-film device beneath the tabletop.

41.1(3) Administrative controls.

a. Registrant. The registrant shall be responsible for maintaining in accordance with manufacturer specifications and directing the operation of the X-ray system(s) under the registrant’s administrative control. Where no manufacturer specifications are indicated, X-ray systems shall be serviced annually. All service and installation shall be performed by persons registered under 641—subrule 39.3(3). The registrant or the registrant’s agent shall ensure that the requirements of these rules are met in the operation of the X-ray system(s).

(1) An X-ray system which does not meet the provisions of these rules shall not be operated for diagnostic or therapeutic purposes unless so directed by the agency.

(2) Individuals who will be operating the X-ray systems shall be adequately instructed in safe operating procedures and be competent in the safe use of the equipment in accordance with 641—Chapter 42 as applicable. The individual’s permit to practice shall be posted in the immediate vicinity of the general work area and visible to the public.

(3) A chart shall be provided in the vicinity of the diagnostic X-ray system’s control panel which specifies, for all examinations performed with that system, the following information:

1. Patient’s anatomical size versus technique factors to be utilized;
2. Type and size of the film or film-screen combination to be used;
3. Type and focal distance of the grid to be used, if any;
4. Source to image receptor distance to be used, except for dental intra-oral radiography; and
5. Type and location of placement of human patient shielding to be used (e.g., gonad).

(4) Written safety procedures shall be provided to each individual operating X-ray equipment, including patient holding and any restrictions of the operating technique required for the safe operation of the particular X-ray system. The operator shall be able to demonstrate familiarity with these procedures.

(5) Except for patients who cannot be moved out of the room, only the staff and ancillary personnel required for the medical procedure or training shall be in the room during the radiographic exposure. Other than the patient being examined:

1. All individuals shall be positioned such that no part of the body will be struck by the useful beam unless protected by 0.5 millimeter lead equivalent.
2. Staff and ancillary personnel shall be protected from the direct scatter radiation by protective aprons or whole body protective barriers of not less than 0.25 millimeter lead equivalent.
3. Human patients who cannot be removed from the room shall be protected from the direct scatter radiation by whole body protective barriers of 0.25 millimeter lead equivalent or shall be so positioned that the nearest portion of the body is at least 2 meters from both the tube head and the nearest edge of the image receptor.

(6) Gonad shielding of not less than 0.25 millimeter lead equivalent shall be used for human patients, who have not passed the reproductive age, during radiographic procedures in which the gonads are in the useful beam, except for cases in which this would interfere with the diagnostic procedure.

(7) Individuals shall not be exposed to the useful beam except for healing arts purposes and unless such exposure has been authorized by a licensed practitioner of the healing arts. This provision specifically prohibits deliberate exposure for the following purposes:

1. Exposure of an individual for training, demonstration, or other nonhealing arts purposes; and
2. Exposure of an individual for the purpose of healing arts screening except as authorized by 41.1(3)“a”(11).

(8) When a patient or film must be provided with auxiliary support during a radiation exposure:

1. Mechanical holding devices shall be used when the technique permits. The written safety procedures, required by 41.1(3)“a”(4), shall list individual projections where holding devices cannot be utilized;

2. Written safety procedures, as required by 41.1(3)“a”(4), shall indicate the requirements for selecting a holder and the procedure the holder shall follow;

3. The human holder shall be protected as required by 41.1(3)“a”(5)“2”;

4. No individual shall be used routinely to hold film or patients; and

5. In those cases where the human patient must hold the film, except during intraoral examinations, any portion of the body other than the area of clinical interest struck by the useful beam shall be protected by not less than 0.5 millimeter lead equivalent material.

6. Each facility shall have leaded aprons and gloves available in sufficient numbers to provide protection to all personnel who are involved with X-ray operations and who are otherwise not shielded.

(9) Procedures and auxiliary equipment designed to minimize patient and personnel exposure commensurate with the needed diagnostic information shall be utilized.

1. The speed of film or screen and film combinations shall be the fastest speed consistent with the diagnostic objective of the examinations. Film cassettes without intensifying screens shall not be used for any routine diagnostic radiological imaging, with the exception of veterinary radiography and standard film packets for intra-oral use in dental radiography.

2. The radiation exposure to the patient shall be the minimum exposure required to produce images of good diagnostic quality.

3. Portable or mobile X-ray equipment shall be used only for examinations where it is impractical to transfer the patient(s) to a stationary X-ray installation.

4. X-ray systems subject to 41.1(6) shall not be utilized in procedures where the source to human patient distance is less than 30 centimeters.

5. If grids are used between the patient and the image receptor to decrease scatter to the film and improve contrast, the grid shall:

- Be positioned properly, i.e., tube side facing the correct direction, and the grid centered to the central ray;

- If of the focused type, be at the proper focal distance for the SIDs being used.

(10) All individuals who are associated with the operation of an X-ray system are subject to the requirements of 641—subrule 40.36(3) and rules 641—40.15(136C) and 641—40.37(136C). In addition:

1. When protective clothing or devices are worn on portions of the body and a personnel monitoring device(s) is present, it (they) shall be worn in accordance with the recommendations found in Chapter 4 of the National Council of Radiation Protection and Measurements Report No. 57.

2. Exposure of a personnel monitoring device to deceptively indicate a dose delivered to an individual is prohibited.

(11) Healing arts screening. Any person proposing to conduct a healing arts screening program shall not initiate such a program without prior approval of the agency. When requesting such approval, that person shall submit the information outlined in Appendix C of this chapter. If any information submitted to the agency becomes invalid or outdated, the agency shall be immediately notified.

b. Information and maintenance record and associated information. The registrant shall maintain the following information for each X-ray system for inspection by the agency:

- (1) Model and serial numbers of all major components and user's manual for those components;
- (2) Tube rating charts and cooling curves;
- (3) Records of surveys, calibrations, maintenance, and modifications performed on the X-ray system(s) with the names of persons who performed such services;
- (4) A copy of all correspondence with this agency regarding that X-ray system.

c. X-ray utilization log. Except for veterinary facilities, each facility shall maintain an X-ray log containing the patient's name, the type of examinations, the dates the examinations were performed, and the number of retakes involved. When the patient or film must be provided with human auxiliary support, the name of the human holder shall be recorded.

d. Plan review.

(1) Prior to construction of all new installations, or modifications of existing installations, or installation of equipment into existing facilities utilizing X-rays for diagnostic or therapeutic purposes, the floor plans and equipment arrangements shall be submitted to the agency for review and approval. The required information is denoted in Appendices A and B of this chapter.

(2) The agency may require the applicant to utilize the services of a qualified expert to determine the shielding requirements prior to the plan review and approval.

(3) The approval of such plans shall not preclude the requirement of additional modifications should a subsequent analysis of operating conditions indicate the possibility of an individual receiving a dose in excess of the limits prescribed in 641—Chapter 40.

e. Federal performance standards. All X-ray equipment shall comply with the applicable performance standards of 21 CFR 1020.30 to 1020.40 which were in effect at the time the unit was manufactured. All equipment manufactured before the effective date of 21 CFR 1020.30 to 1020.40 shall meet the requirements of the Iowa rules. Persons registered to possess the affected radiation-emitting equipment in Iowa shall be responsible for maintaining the equipment in compliance with the appropriate federal performance standards.

f. X-ray film processing facilities and practices (except for mammography). Each installation using a radiographic X-ray system and using analog image receptors (e.g., radiographic film) shall have available suitable equipment for handling and processing radiographic film in accordance with the following provisions:

(1) Manually developed film.

1. Processing tanks shall be constructed of mechanically rigid, corrosion-resistant material; and

2. The temperature of solutions in the tanks shall be maintained within the range of 60°F to 80°F (16°C to 27°C). Film shall be developed in accordance with the time-temperature relationships recommended by the film manufacturer or, in the absence of such recommendations, with the time-temperature chart available from the agency.

3. Devices shall be utilized which will indicate the actual temperature of the developer and signal the passage of a preset time appropriate to the developing time required.

(2) Automatic processors and other closed processing systems.

1. Films shall be developed in accordance with the time-temperature relationships recommended by the film manufacturer; in the absence of such recommendations, the film shall be developed using the chart available from the agency.

2. Processing deviations from the requirements of 41.1(3) "f" shall be documented by the registrant in such manner that the requirements are shown to be met or exceeded (e.g., extended processing and special rapid chemistry).

(3) Other requirements.

1. Pass boxes, if provided, shall be so constructed as to exclude light from the darkroom when cassettes are placed in or removed from the boxes, and shall incorporate adequate shielding from stray radiation to prevent exposure of undeveloped film.

2. The darkroom shall be light tight and use proper safelighting such that any film type in use exposed in a cassette to X-radiation sufficient to produce an optical density from 1 to 2 when processed shall not suffer an increase in density greater than 0.1 when exposed out of the cassette in the darkroom for 2 minutes with all safelights on. If used, daylight film handling boxes shall preclude fogging of the film.

3. Darkrooms typically used by more than one individual shall be provided a method to prevent accidental entry while undeveloped films are being handled or processed.

4. Film shall be stored in a cool, dry place and shall be protected from exposure to stray radiation. Film in open packages shall be stored in a light tight container.

5. Film cassettes and intensifying screens shall be inspected periodically and shall be cleaned and replaced as necessary to best ensure radiographs of good diagnostic quality.

6. Outdated X-ray film shall not be used for diagnostic radiographs, unless the film has been stored in accordance with the manufacturer's recommendations and a sample of the film passes a sensitometric test for normal ranges of base plus fog and speed.

7. Film developing solutions shall be prepared in accordance with the directions given by the manufacturer and shall be maintained in strength by replenishment or renewal so that full development is accomplished within the time specified by the manufacturer.

41.1(4) General requirements for all diagnostic X-ray systems. In addition to other requirements of this chapter, all diagnostic X-ray systems shall meet the following requirements:

a. Warning label. The control panel containing the main power switch shall bear the warning statement, legible and accessible to view: "WARNING: This X-ray unit may be dangerous to patient and operator unless safe exposure factors and operating instructions are observed."

b. Battery charge indicator. On battery-powered X-ray generators, visual means shall be provided on the control panel to indicate whether the battery is in a state of charge adequate for proper operation.

c. Leakage radiation from the diagnostic source assembly. The leakage radiation from the diagnostic source assembly measured at a distance of 1 meter in any direction from the source shall not exceed 100 milliroentgens ($25.8 \mu\text{C/kg}$) in one hour when the X-ray tube is operated at its leakage technique factors. Compliance shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.

d. Radiation from components other than the diagnostic source assembly. The radiation emitted by a component other than the diagnostic source assembly shall not exceed 2 milliroentgens ($0.516 \mu\text{C/kg}$) in one hour at 5 centimeters from any accessible surface of the component when it is operated in an assembled X-ray system under any conditions for which it was designed. Compliance shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.

e. Beam quality.

(1) Half-value layer.

1. The half-value layer of the useful beam for a given X-ray tube potential shall not be less than the values shown in Table I. If it is necessary to determine such half-value layer at an X-ray tube potential which is not listed in Table I, linear interpolation or extrapolation may be made.

Table I

Design operating range (kVp)	Measured potential (kVp)	Half-value layer (mm of aluminum)
Below 50	30	0.3
	40	0.4
	49	0.5
50 to 70	50	1.2
	60	1.3
	70	1.5
Above 70	71	2.1
	80	2.3
	90	2.5
	100	2.7
	110	3.0
	120	3.2
	130	3.5
	140	3.8
	150	4.1

2. and 3. Rescinded IAB 4/8/98, effective 7/1/98.

4. For capacitor energy storage equipment, compliance with the requirements of 41.1(4)“e” shall be determined with the system fully charged and a setting of 10 mAs for each exposure.

5. The required minimal half-value layer of the useful beam shall include the filtration contributed by all materials which are permanently between the source and the patient.

(2) Filtration controls. For X-ray systems which have variable kVp and variable filtration for the useful beam, a device shall link the kVp selector with the filter(s) and shall prevent an exposure unless the minimum amount of filtration required by 41.1(4)“e”(1)“1” is in the useful beam for the given kVp which has been selected.

f. Multiple tubes. Where two or more radiographic tubes are controlled by one exposure switch, the tube or tubes which have been selected shall be clearly indicated prior to initiation of the exposure. This indication shall be both on the X-ray control panel and at or near the tube housing assembly which has been selected.

g. Mechanical support of tube head. The tube housing assembly supports shall be adjusted such that the tube housing assembly will remain stable during an exposure unless tube housing movement is a designed function of the X-ray system.

h. Technique indicators.

(1) The technique factors to be used during an exposure shall be indicated before the exposure begins. If automatic exposure controls are used, the technique factors which are set prior to the exposure shall be indicated.

(2) The requirement of 41.1(4) "h"(1) may be met by permanent markings on equipment having fixed technique factors. Indication of technique factors shall be visible from the operator's position except in the case of spot films made by the fluoroscopist.

(3) The technique indicators shall be accurate to within manufacturer's standards.

i. Locks. All position locking, holding, and centering devices on X-ray system components and systems shall function as intended.

41.1(5) *Fluoroscopic X-ray systems except for computed tomography X-ray systems.* All fluoroscopic X-ray systems shall be image intensified and meet the following requirements:

a. Limitation of useful beam.

(1) Primary barrier.

1. The fluoroscopic imaging assembly shall be provided with a primary protective barrier which intercepts the entire cross section of the useful beam at any SID.

2. The X-ray tube used for fluoroscopy shall not produce X-rays unless the barrier is in position to intercept the entire useful beam.

(2) Fluoroscopic beam limitation.

1. For certified fluoroscopic systems with or without a spot film device, neither the length nor the width of the X-ray field in the plane of the image receptor shall exceed that of the visible area of the image receptor by more than 3 percent of the SID. The sum of the excess length and the excess width shall be no greater than 4 percent of the SID.

2. For uncertified fluoroscopic systems with a spot film device, the X-ray beam with the shutter fully opened (during fluoroscopy or spot filming) shall be no larger than the largest spot film size for which the device is designed. Measurements shall be made at the minimum SID available but at no less than 20 centimeters from the tabletop to the film plane distance.

3. For uncertified fluoroscopic systems without a spot film device, the requirements of 41.1(5) "a"(2) "1" apply.

4. Other requirements for fluoroscopic beam limitation:

- Means shall be provided to permit further limitation of the field. Beam-limiting devices manufactured after May 22, 1979, and incorporated in equipment with a variable SID or a visible area of greater than 300 square centimeters shall be provided with means for stepless adjustment of the X-ray field;

- All equipment with a fixed SID and a visible area of 300 square centimeters or less shall be provided either with stepless adjustment of the X-ray field or with means to further limit the X-ray field size at the plane of the image receptor to 125 square centimeters or less;

- If provided, stepless adjustment shall, at the greatest SID, provide continuous field sizes from the maximum attainable to a field size of 5 centimeters by 5 centimeters or less;

- For equipment manufactured after February 25, 1978, when the angle between the image receptor and beam axis is variable, means shall be provided to indicate when the axis of the X-ray beam is perpendicular to the plane of the image receptor;

- For noncircular X-ray fields used with circular image receptors, the error in alignment shall be determined along the length and width dimensions of the X-ray field which pass through the center of the visible area of the image receptor.

(3) Spot-film beam limitation. Spot-film devices shall meet the following requirements:

1. Means shall be provided between the source and the patient for adjustment of the X-ray field size in the plane of the film to the size of that portion of the film which has been selected on the spot-film selector. Such adjustment shall be automatically accomplished except when the X-ray field size in the plane of the film is smaller than that of the selected portion of the film. For spot-film devices manufactured after June 21, 1979, if the X-ray field size is less than the size of the selected portion of the film, the means for adjustment of the field size shall be only at the operator's option;

2. Neither the length nor the width of the X-ray field in the plane of the image receptor shall differ from the corresponding dimensions of the selected portion of the image receptor by more than 3 percent of the SID when adjusted for full coverage of the selected portion of the image receptor. The sum, without regard to sign, of the length and width differences shall not exceed 4 percent of the SID;

3. It shall be possible to adjust the X-ray field size in the plane of the film to a size smaller than the selected portion of the film. The minimum field size at the greatest SID shall be equal to, or less than, 5 centimeters by 5 centimeters;

4. The center of the X-ray field in the plane of the film shall be aligned with the center of the selected portion of the film to within 2 percent of the SID; and

5. On spot-film devices manufactured after February 25, 1978, if the angle between the plane of the image receptor and beam axis is variable, means shall be provided to indicate when the axis of the X-ray beam is perpendicular to the plane of the image receptor, and compliance shall be determined with the beam axis indicated to be perpendicular to the plane of the image receptor.

(4) Override. If a means exists to override any of the automatic X-ray field size adjustments required in 41.1(5) "a"(2) and 41.1(5) "a"(3), that means:

1. Shall be designed for use only in the event of system failure;

2. Shall incorporate a signal visible at the fluoroscopist's position which will indicate whenever the automatic field size adjustment is overridden; and

3. Shall have a clear and durable label as follows:

FOR X-RAY FIELD LIMITATION SYSTEM FAILURE

b. Activation of the fluoroscopic tube. X-ray production in the fluoroscopic mode shall be controlled by a device which requires continuous pressure by the fluoroscopist for the entire time of any exposure. When recording serial fluoroscopic images, the fluoroscopist shall be able to terminate the X-ray exposure(s) at any time, but means may be provided to permit completion of any single exposure of the series in process.

c. Exposure rate limits.

(1) Entrance exposure rate allowable limits.

1. Fluoroscopic equipment which is provided with automatic exposure rate control shall not be operable at any combination of tube potential and current which will result in an exposure rate in excess of 2.6 mC/kg (10 roentgens) per minute at the point where the center of the useful beam enters the patient, except:

- During recording of fluoroscopic images; or

- When an optional high level control is provided. When so provided, the equipment shall not be operable at any combination of tube potential and current which will result in an exposure rate in excess of 1.3 mC/kg (5 roentgens) per minute at the point where the center of the useful beam enters the patient unless the high level control is activated. Special means of activation of high level controls shall be required. The high level control shall only be operable when continuous manual activation is provided by the operator. A continuous signal audible to the fluoroscopist shall indicate that the high level control is being employed.

2. Fluoroscopic equipment which is not provided with automatic exposure rate control shall not be operable at any combination of tube potential and current which will result in an exposure rate in excess of 1.3 mC/kg (5 roentgens) per minute at the point where the center of the useful beam enters the patient, except:

- During recording of fluoroscopic images; or
- When an optional high level control is activated. Special means of activation of high level controls shall be required. The high level control shall only be operable when continuous manual activation is provided by the operator. A continuous signal audible to the fluoroscopist shall indicate that the high level control is being employed.

3. Compliance with the requirements of 41.1(5)“c” shall be determined as follows: movable grids and compression devices shall be removed from the useful beam during the measurement;

- If the source is below the table, exposure rate shall be measured 1 centimeter above the tabletop or cradle;

- If the source is above the table, the exposure rate shall be measured at 30 centimeters above the tabletop with the end of the beam-limiting device or spacer positioned as closely as possible to the point of measurement;

- All C-arm fluoroscopes, both stationary and mobile, shall meet the entrance exposure rate limits at 30 centimeters from the input surface of the fluoroscopic imaging assembly with the source positioned at any available SID provided that the end of the spacer assembly or beam-limiting device is not closer than 30 centimeters from the input surface of the fluoroscopic imaging assembly.

- For a lateral type fluoroscope, the exposure rate shall be measured at a point 15 centimeters from the centerline of the X-ray table and in the direction of the X-ray source with the end of the beam-limiting device or spacer positioned as closely as possible to the point of measurement. If the tabletop is movable, it shall be positioned as closely as possible to the lateral X-ray source, with the end of the beam-limiting device or spacer no closer than 15 centimeters to the centerline of the X-ray table.

4. Periodic measurement of entrance exposure rate shall be performed by a qualified expert for both typical and maximum values as follows: Such measurements shall be made annually or after any maintenance of the system which might affect the exposure rate; results of these measurements shall be posted where any fluoroscopist may have ready access to such results while using the fluoroscope and in the record required in 41.1(3)“b”(5). The measurement results shall be stated in roentgens per minute and include the technique factors used in determining such results. The name of the individual performing the measurements and the date the measurements were performed shall be included in the results. Conditions of periodic measurement of entrance exposure rate are as follows:

- The measurement shall be made under the conditions that satisfy the requirements of 41.1(5)“c”(1)“2”;

- The kVp mA, and other selectable parameters shall be adjusted to those settings typical of clinical use on a 23 cm thick abdominal patient;

- The X-ray system(s) that incorporates automatic exposure rate control shall have sufficient attenuative material placed in the useful beam to produce the maximum entrance exposure rate of the system.

(2) Reserved.

d. Barrier transmitted radiation rate limits.

(1) The exposure rate due to transmission through the primary protective barrier with the attenuation block in the useful beam, combined with radiation from the image intensifier, if provided, shall not exceed 2 milliroentgens ($0.516 \mu\text{C/kg}$) per hour at 10 centimeters from any accessible surface of the fluoroscopic imaging assembly beyond the plane of the image receptor for each roentgen per minute of entrance exposure rate.

(2) Measuring compliance of barrier transmission.

1. The exposure rate due to transmission through the primary protective barrier combined with radiation from the image intensifier shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.

2. If the source is below the tabletop, the measurement shall be made with the input surface of the fluoroscopic imaging assembly positioned 30 centimeters above the tabletop.

3. If the source is above the tabletop and the SID is variable, the measurement shall be made with the end of the beam-limiting device or spacer as close to the tabletop as it can be placed, provided that it shall not be closer than 30 centimeters.

4. Movable grids and compression devices shall be removed from the useful beam during the measurement.

e. Indication of potential and current. During fluoroscopy and cinefluorography the kV and the mA shall be continuously indicated.

f. Source-to-skin distance. The SSD shall not be less than:

- (1) 38 centimeters on stationary fluoroscopes installed on or after August 1, 1974,
 - (2) 35.5 centimeters on stationary fluoroscopes which were in operation prior to August 1, 1974,
 - (3) 30 centimeters on all mobile fluoroscopes, and
 - (4) 20 centimeters for image-intensified fluoroscopes used for specific surgical application.
- (5) The written safety procedures must provide precautionary measures to be adhered to during the use of this device in addition to the procedures provided in 41.1(3)“a”(4).

g. Fluoroscopic timer.

(1) Means shall be provided to preset the cumulative on-time of the fluoroscopic X-ray tube. The maximum cumulative time of the timing device shall not exceed five minutes without resetting.

(2) A signal audible to the fluoroscopist shall indicate the completion of any preset cumulative on-time. Such signal shall continue to sound while X-rays are produced until the timing device is reset.

h. Control of scattered radiation.

(1) Fluoroscopic table designs when combined with procedures utilized shall be such that no unprotected part of any staff or ancillary individual's body shall be exposed to unattenuated scattered radiation which originates from under the table. The attenuation required shall be not less than 0.25 millimeter lead equivalent.

(2) Equipment configuration when combined with procedures shall be such that no portion of any staff or ancillary individual's body, except the extremities, shall be exposed to the unattenuated scattered radiation emanating from above the tabletop unless that individual:

1. Is at least 120 centimeters from the center of the useful beam, or
2. The radiation has passed through not less than 0.25 millimeter lead equivalent material including, but not limited to, drapes, Bucky-slot cover panel, or self-supporting curtains, in addition to any lead equivalency provided by the protective apron referred to in 41.1(3)“a”(5).

(3) The agency may grant exemptions to 41.1(5)“h”(2) where a sterile field will not permit the use of the normal protective barriers. Where the use of prefitted sterilized covers for the barriers is practical, the agency shall not permit such exemption.

i. Spot-film exposure reproducibility. Fluoroscopic systems equipped with spot-film (radio-graphic) mode shall meet the exposure reproducibility requirements of 41.1(6)“d” when operating in the spot-film mode.

j. Radiation therapy simulation systems. Radiation therapy simulation systems shall be exempt from all the requirements of 41.1(5)“a,” “c,” “d,” and “g” provided that:

(1) Such systems are designed and used in such a manner that no individual other than the patient is in the X-ray room during periods of time when the system is producing X-rays; and

(2) Systems which do not meet the requirements of 41.1(5)“g” are provided with a means of indicating the cumulative time that an individual patient has been exposed to X-rays. Procedures shall require in such cases that the timer be reset between examinations.

41.1(6) Radiographic systems other than fluoroscopic, dental intraoral, or computed tomography X-ray systems.

a. Beam limitation. The useful beam shall be limited to the area of clinical interest. This shall be considered met if a positive beam-limiting device meeting manufacturer’s specifications and the requirements of 41.1(6)“h”(2) have been properly used or if evidence of collimation is shown on at least three sides or three corners of the film (for example, projections from the shutters of the collimator, cone cutting at the corners, or borders at the film’s edge.)

(1) General purpose stationary and mobile X-ray systems and veterinarian systems (other than portable) installed after July 1, 1998.

1. Only X-ray systems provided with means for independent stepless adjustment of at least two dimensions of the X-ray field shall be used.

2. A method shall be provided for visually defining the perimeter of the X-ray field.

• Illuminance shall be greater than 7.5 foot-candles or 80.3 LUX at 100 centimeters or maximum SID whichever is less.

• The total misalignment of the edges of the visually defined field with the respective edges of the X-ray field along either the length or width of the visually defined field shall not exceed 2 percent of the distance from the source to the center of the visually defined field when the surface upon which it appears is perpendicular to the axis of the X-ray beam.

3. The agency may grant an exemption on noncertified X-ray systems to 41.1(6)“a”(1)“1” and “2” provided the registrant makes a written application for such exemption and in that application demonstrates it is impractical to comply with 41.1(6)“a”(1)“1” and “2”; and the purpose of 41.1(6)“a”(1)“1” and “2” will be met by other methods.

(2) Additional requirements for stationary general purpose X-ray systems. In addition to the requirements of 41.1(6)“a”(1), stationary general purpose X-ray systems, both certified and noncertified, shall meet the following requirements:

1. A method shall be provided to indicate when the axis of the X-ray beam is perpendicular to the plane of the image receptor, to align the center of the X-ray field with respect to the center of the image receptor to within 2 percent of the SID, and to indicate the SID to within 2 percent;

2. The beam-limiting device shall indicate numerically the field size in the plane of the image receptor to which it is adjusted; and

3. Indication of field size dimensions and SIDs shall be specified in inches or centimeters, and shall be such that aperture adjustments result in X-ray field dimensions in the plane of the image receptor which correspond to those indicated by the beam-limiting device to within 2 percent of the SID when the beam axis is indicated to be perpendicular to the plane of the image receptor.

(3) X-ray systems designed for one image receptor size. Radiographic equipment designed for only one image receptor size at a fixed SID shall be provided with means to limit the field at the plane of the image receptor to dimensions no greater than those of the image receptor, and to align the center of the X-ray field with the center of the image receptor to within 2 percent of the SID, or shall be provided with means to both size and align the X-ray field such that the X-ray field at the plane of the image receptor does not extend beyond any edge of the image receptor.

(4) Systems designed for or provided with special attachments for mammography. Rescinded IAB 4/8/98, effective 7/1/98.

(5) X-ray systems other than those described in 41.1(6)“a”(1), (2), and (3), and veterinary systems installed prior to July 1, 1998.

1. Means shall be provided to limit the X-ray field in the plane of the image receptor so that such field does not exceed each dimension of the image receptor by more than 2 percent of the SID when the axis of the X-ray beam is perpendicular to the plane of the image receptor.

2. Means shall be provided to align the center of the X-ray field with the center of the image receptor to within 2 percent of the SID, or means shall be provided to both size and align the X-ray field such that the X-ray field at the plane of the image receptor does not extend beyond any edge of the image receptor. Compliance shall be determined with the axis of the X-ray beam perpendicular to the plane of the image receptor.

3. 41.1(6)“a”(5)“1” and “2” may be met with a system that meets the requirements for a general purpose X-ray system as specified in 41.1(6)“a”(1) or, when alignment means are also provided, may be met with either:

- An assortment of removable, fixed-aperture, beam-limiting devices sufficient to meet the requirement for each combination of image receptor size and SID for which the unit is designed with each such device having clear and permanent markings to indicate the image receptor size and SID for which it is designed; or

- A beam-limiting device having multiple fixed apertures sufficient to meet the requirement for each combination of image receptor size and SID for which the unit is designed. Permanent, clearly legible markings shall indicate the image receptor size and SID for which each aperture is designed and shall indicate which aperture is in position for use.

b. Radiation exposure control devices.

(1) Timers. Means shall be provided to terminate the exposure at a preset time interval, preset product of current and time, a preset number of pulses, or a preset radiation exposure to the image receptor. In addition, it shall not be possible to make an exposure when the timer is set to a “zero” or “off” position if either position is provided. Except for dental panoramic systems, termination of an exposure shall cause automatic resetting of the timer to its initial setting or to “zero.”

(2) X-ray control.

1. Manual exposure control. An X-ray control shall be incorporated into each X-ray system such that an exposure can be terminated by the operator at any time except for exposure of one-half second or less, or during serial radiography when means shall be provided to permit completion of any single exposure of the series in process.

2. Each X-ray control shall be located in such a way as to meet the following requirements: Stationary X-ray systems (except podiatry and veterinary units) shall be required to have the X-ray exposure switch permanently mounted in a protected area so that the operator is required to remain in that protected area during the entire exposure; and mobile and portable X-ray systems which are:

- Used for greater than one week in the same location, i.e., a room or suite, shall meet the requirements of 41.1(6)“b”(2)“2”; or

- Used for greater than one hour and less than one week at the same location, i.e., a room or suite, or in a clinical setting for routine extremities only, shall meet the requirement of the above paragraph or be provided with a 6.5 foot (1.98 m) high protective barrier which is placed at least 2.7 meters (9 feet) from the tube housing assembly.

3. The X-ray control shall provide visual indication observable at or from the operator's protected position whenever X-rays are produced. In addition, a signal audible to the operator shall indicate that the exposure has terminated.

(3) Automatic exposure controls. When an automatic exposure control is provided:

1. Indication shall be made on the control panel when this mode of operation is selected;

2. If the X-ray tube potential is equal to or greater than 50 kVp, the minimum exposure time for field emission equipment rated for pulsed operation shall be equal to or less than a time interval equivalent to 2 pulses;

3. The minimum exposure time for all equipment other than that specified in 41.1(6)"b"(3)"2" shall be equal to or less than one-sixtieth second or a time interval required to deliver 5 mAs, whichever is greater;

4. Either the product of peak X-ray tube potential, current, and exposure time shall be limited to not more than 60 kW per exposure, or the product of X-ray tube current and exposure time shall be limited to not more than 600 mAs per exposure except that, when the X-ray tube potential is less than 50 kVp, the product of X-ray tube current and exposure time shall be limited to not more than 2000 mAs per exposure; and

5. A visible signal shall indicate when an exposure has been terminated at the limits required by 41.1(6)"b"(3)"4," and manual resetting shall be required before further automatically timed exposures can be made.

(4) Reproducibility. With a timer setting of 0.5 seconds or less, the average exposure period (T) shall be greater than or equal to five times the maximum exposure period (T_{\max}) minus the minimum exposure period (T_{\min}) when four timer tests are performed:

$$\bar{T} \geq 5 (T_{\max} - T_{\min})$$

(5) Exposure duration (timer) linearity. For systems having independent selection of exposure time settings, the average ratios (X_1) of exposure to the indicated timer setting, in units of $C \text{ kg}^{-1}\text{s}^{-1}$ (mR/s), obtained at any two clinically used timer settings shall not differ by more than 0.10 times their sum. This is written as:

$$(X_1 - X_2) \leq 0.1 (X_1 + X_2)$$

where X_1 and X_2 are the average $C \text{ kg}^{-1}\text{s}^{-1}$ (mR/s) values.

c. Source-to-skin distance. All mobile or portable radiographic systems shall be provided with means to limit the source-to-skin distance to equal to or greater than 30 centimeters except for veterinary systems.

d. Exposure reproducibility. The coefficient of variation of exposure shall not exceed 0.05 when all technique factors are held constant. This requirement applies to clinically used techniques. This requirement shall be deemed to have been met if, when four exposures are made at identical technique factors, the value of the average exposure (\bar{E}) is greater than or equal to five times the maximum exposure (E_{\max}) minus the minimum exposure (E_{\min}):

$$\bar{E} \geq 5 (E_{\max} - E_{\min})$$

e. Radiation from capacitor energy storage equipment in standby status. Radiation emitted from the X-ray tube when the exposure switch or timer is not activated shall not exceed a rate of 2 milliroentgens ($0.516 \mu\text{C/kg}$) per hour at 5 centimeters from any accessible surface of the diagnostic source assembly, with the beam-limiting device fully open.

f. Accuracy. Deviation of measured technique factors from indicated values of kVp and exposure time shall not exceed the limits specified for that system by its manufacturer. In the absence of manufacturer's specifications, the deviation shall not exceed 10 percent of the indicated value for kVp and 20 percent for time.

g. mA/mAs linearity. The following requirements apply when the equipment is operated on a power supply as specified by the manufacturer for any fixed X-ray tube potential within the range of 40 percent to 100 percent of the maximum rated:

(1) Equipment having independent selection of X-ray tube current (mA). The average ratios (X_i) of exposure to the indicated milliamperere-seconds product ($\text{C kg}^{-1}\text{mAs}^{-1}$ (or mR/mAs)) obtained at any two consecutive tube current settings shall not differ by more than 0.10 times their sum:

$$X_1 - X_2 \leq 0.10 (X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at each of two consecutive tube current settings, or at two settings differing by no more than a factor of 2 where the tube current selection is continuous.

(2) Equipment having a combined X-ray tube current-exposure time product (mAs) selector, but not a separate tube current (mA) selector. The average ratios (X_i) of exposure to the indicated milliamperere-seconds product, in units of $\text{C kg}^{-1}\text{mAs}^{-1}$ (or mR/mAs), obtained at any two consecutive mAs selector settings shall not differ by more than 0.10 times their sum:

$$X_1 - X_2 \leq 0.10 (X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at any two mAs selector settings, or at two settings differing by no more than a factor of 2 where the mAs selector provides continuous selection.

(3) Measuring compliance. Determination of compliance shall be based on 10 exposures taken within a time period of one hour, at each of the two settings. These two settings may include any two focal spot sizes except where one is equal to or less than 0.45 millimeters and the other is greater than 0.45 millimeters. For purposes of this requirement, focal spot size is the nominal focal spot size specified by the X-ray tube manufacturer.

h. Additional requirements applicable to certified systems only. Diagnostic X-ray systems incorporating one or more certified component(s) shall be required to comply with the following additional requirement(s) which relate to that certified component(s).

(1) Beam limitation for stationary and mobile general purpose X-ray systems.

1. There shall be provided a means of stepless adjustment of the X-ray field. The minimum field size at an SID of 100 centimeters shall be equal to or less than 5 centimeters by 5 centimeters.

2. When a light localizer is used to define the X-ray field, it shall provide an average illumination of not less than 160 lux or 15 foot-candles at 100 centimeters or at the maximum SID, whichever is less. The average illumination shall be based upon measurements made in the approximate center of each quadrant of the light field. Radiation therapy simulation systems manufactured on and after May 27, 1980, are exempt from this requirement.

3. The edge of the light field at 100 centimeters or at the maximum SID, whichever is less, shall have a contrast ratio, corrected for ambient lighting, of not less than 4 in the case of beam-limiting devices designed for use on stationary equipment, and a contrast ratio of not less than 3 in the case of beam-limiting devices designed for use on mobile equipment. The contrast ratio is defined as I_1/I_2 where I_1 is the illumination 3 millimeters from the edge of the light field toward the center of the field; and I_2 is the illumination 3 millimeters from the edge of the light field away from the center of the field. Compliance shall be determined with a measuring instrument aperture of 1 millimeter in diameter.

(2) Beam limitation and alignment on stationary general purpose X-ray systems equipped with PBL. If PBL is being used, the following requirements shall be met:

1. PBL shall prevent the production of X-rays when:

- Either the length or width of the X-ray field in the plane of the image receptor differs, except as permitted by 41.1(6)“h”(3), from the corresponding image receptor dimensions by more than 3 percent of the SID; or

- The sum of the length and width differences as stated in 41.1(6)“h”(2)“1” above without regard to sign exceeds 4 percent of the SID;

2. Compliance with 41.1(6)“h”(2)“1” shall be determined when the equipment indicates that the beam axis is perpendicular to the plane of the image receptor. Compliance shall be determined no sooner than 5 seconds after insertion of the image receptor;

3. The PBL system shall be capable of operation, at the discretion of the operator, such that the size of the field may be made smaller than the size of the image receptor through stepless adjustment of the field size. The minimum field size at an SID of 100 centimeters shall be equal to or less than 5 centimeters by 5 centimeters;

4. The PBL system shall be designed such that if a change in image receptor does not cause an automatic return to PBL function as described in 41.1(6)“h”(2)“1,” then any change of image receptor size or SID must cause the automatic return.

(3) Beam limitation for portable X-ray systems. Beam limitation for portable X-ray systems shall meet the beam limitation requirements of 41.1(6)“a” or 41.1(6)“h”(2).

i. Tube stands for portable X-ray systems. A tube stand or other mechanical support shall be used for portable X-ray systems, so that the X-ray tube housing assembly need not be handheld during exposures.

41.1(7) Intraoral dental radiographic systems. In addition to the provisions of 41.1(3) and 41.1(4), the requirements of 41.1(7) apply to X-ray equipment and associated facilities used for dental radiography. Requirements for extraoral dental radiographic systems are covered in 41.1(6). Only systems meeting the requirements of 41.1(7) shall be used.

a. *Source-to-skin distance.* X-ray systems designed for use with an intraoral image receptor shall be provided with means to limit source-to-skin distance to not less than:

- (1) 18 centimeters if operable above 50 kVp, or
- (2) 10 centimeters if not operable above 50 kVp.

b. *Beam limitation.* Radiographic systems designed for use with an intraoral image receptor shall be provided with means to limit the X-ray beam such that:

- (1) If the minimum source-to-skin distance (SSD) is 18 centimeters or more, the X-ray field, at the minimum SSD, shall be containable in a circle having a diameter of no more than 7 centimeters; and
- (2) If the minimum SSD is less than 18 centimeters, the X-ray field, at the minimum SSD, shall be containable in a circle having a diameter of no more than 6 centimeters.

(3) The position indicating device shall be shielded and open-ended. The shielding shall be equivalent to the requirements of 41.1(4)“c.”

c. *Exposure control.*

(1) Exposure initiation.

1. Means shall be provided to initiate the radiation exposure by a deliberate action on the part of the operator, such as the depression of a switch. Radiation exposure shall not be initiated without such an action; and

2. It shall not be possible to make an exposure when the timer is set to a "zero" or "off" position if either position is provided.

(2) Exposure indication. Means shall be provided for visual indication observable at or from the operator's protected position whenever X-rays are produced. In addition, a signal audible to the operator shall indicate that the exposure has terminated.

(3) Exposure termination.

1. Means shall be provided to terminate the exposure at a preset time interval, preset product of current and time, a preset number of pulses, or a preset radiation exposure to the image receptor. In addition:

2. Termination of exposure shall cause automatic resetting of the timer to its initial setting or to "zero."

3. An X-ray control shall be incorporated into each X-ray system such that an exposure can be terminated by the operator at any time, except for exposures of one-half (1/2) second or less.

(4) Exposure duration (timer) linearity. For systems having independent selection of exposure time settings, the average ratios (X_1) of exposure to the indicated timer setting, in units of $C\ kg^{-2}s^{-1}$ (mR/s), obtained at any two clinically used timer settings shall not differ by more than 0.10 times their sum. This is written as:

$$(X_1 - X_2) \leq 0.1 (X_1 + X_2)$$

where X_1 and X_2 are the average values.

(5) Each X-ray exposure switch shall be located in such a way as to meet the following requirements:

1. Stationary X-ray systems shall be required to have the X-ray exposure switch so that the operator is required to remain in the protected area during the entire exposure; and

2. Mobile and portable X-ray systems which are:

- Used for greater than one week in the same location, i.e., a room or suite, shall meet the requirements of 41.1(7) "c"(5) "1."
- Used for greater than one hour and less than one week at the same location, i.e., a room or suite, shall meet the requirements of the above paragraph or be provided with a 6.5 foot (1.98 m) high protective barrier or means to allow the operator to be at least 9 feet (2.7 meters) from the tube housing assembly while making exposure.

d. *Reproducibility.* When the equipment is operated on an adequate power supply as specified by the manufacturer, the estimated coefficient of variation of radiation exposures shall be no greater than 0.05, for any specific combination of selected technique factors.

e. mA/mS linearity. The following requirements apply when the equipment is operated on a power supply as specified by the manufacturer for any fixed X-ray tube potential within the range of 40 percent to 100 percent of the maximum rated.

(1) Equipment having independent selection of X-ray tube current (mA). The average ratios (X_1) of exposure to the indicated milliamperere-seconds product, in units of $C\ kg^{-1}\ mAs^{-1}$ (or mR/mAs), obtained at any two consecutive tube current settings shall not differ by more than 0.10 times their sum:

$$(X_1 - X_2) \leq 0.1 (X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at each of two consecutive tube current settings, or at two settings differing by no more than a factor of 2 where the tube current selection is continuous.

(2) Equipment having a combined X-ray tube current-exposure time product (mAs) selector, but not a separate tube current (mA) selector. The average ratios (X_1) of exposure to the indicated milliamperere-seconds product, in units of $C\ kg^{-1}\ mAs^{-1}$ (or mR/mAs), obtained at any two consecutive mAs selector settings shall not differ by more than 0.10 times their sum:

$$(X_1 - X_2) \leq 0.1 (X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at any two mAs selector settings, or at two settings differing by no more than a factor of 2 where the mAs selector provides continuous selection.

(3) Measuring compliance. Determination of compliance shall be based on 10 exposures taken within a time period of one hour, at each of the two settings. These two settings may include any two focal spot sizes except where one is equal to or less than 0.45 millimeters and the other is greater than 0.45 millimeters. For purposes of this requirement, focal spot size is the nominal focal spot size specified by the X-ray tube manufacturer.

f. Accuracy. Deviation of technique factors from indicated values for kVp and exposure time (if time is independently selectable) shall not exceed the limits specified for that system by its manufacturer. In the absence of manufacturer's specifications the deviation shall not exceed 10 percent of the indicated value for kVp and 20 percent for time.

g. kVp limitations. Dental X-ray machine with a nominal fixed kVp of less than 50 kVp shall not be used to make diagnostic dental radiographs of humans.

h. Administrative controls.

- (1) Patient and film holding devices shall be used when the techniques permit.
- (2) The tube housing and the PID shall not be hand-held during an exposure.
- (3) The X-ray system shall be operated in such a manner that the useful beam at the patient's skin does not exceed the requirements of 41.1(7) "b"(1).

(4) Dental fluoroscopy without image intensification shall not be used.

41.1(8) Rescinded IAB 6/4/97, effective 7/9/97.

41.1(9) Bone densitometry units.

- a.* No additional shielding for the room is required.
- b.* Film badges must be issued for the first six months to all personnel operating the unit. If monitoring indicates no exposure, the IDPH may allow discontinuance of monitoring upon written request. When new procedures are started that have not been previously monitored, monitoring must be reinstated for six months.
- c.* Operators, other than physicians, must possess a health education background to include anatomy and physiology and must complete the manufacturer's training session pertaining to bone densitometry or equivalent. A permit to practice for operators is not required.
- d.* Specific operating procedures must be prepared and made available at the operator's position.

41.1(10) Veterinary medicine radiographic installations.**a. Equipment.**

- (1) The protective tube housing shall be equivalent to the requirements of 41.1(4)“c.”
- (2) Diaphragms or cones shall be provided for collimating the useful beam to the area of clinical interest and shall provide the same degree of protection as is required of the housing.
- (3) The total filtration permanently in the useful beam shall not be less than 0.5 millimeters aluminum equivalent for machines operating up to 50 kVp, 1.5 millimeters aluminum equivalent for machines operating between 50 and 70 kVp, and 2.5 millimeters aluminum equivalent for machines operating above 70 kVp.

b. Operator protection.

- (1) All wall, ceiling, and floor areas shall be equivalent to or provided with applicable protective barriers to ensure compliance with 641—40.15(136C) and 40.21(136C) and subrule 40.26(1).
- (2) All stationary, mobile or portable X-ray systems shall be provided with either a 2 meter (6.5 feet) high protective barrier for operator protections during exposures, or shall be provided with means to allow the operator to be at least 2.7 meters (9 feet) from the tube housing assembly during exposures.

c. Operating procedures.

- (1) No individual other than the operator shall be in the X-ray room while exposures are being made unless such individual's assistance is required, and
- (2) The operator shall stand behind the protective barrier of 9 feet from the useful beam and the animal during radiographic exposures, or
- (3) When an animal must be held in position during radiography, mechanical supporting or restraining devices should be used. If the animal must be held by an individual, that individual shall be protected with appropriate shielding devices, such as protective gloves and apron, and shall be so positioned that no part of the holder's body will be struck by the useful beam. The exposure of any individual used for this purpose shall be monitored.

41.1(11) Computed tomography X-ray systems.

a. Definitions. In addition to the definitions provided in 641—38.2(136C) and 41.1(2), the following definitions shall be applicable to 41.1(11):

“*Computed tomography dose index*” means the integral from $-7T$ to $+7T$ of the dose profile along a line perpendicular to the tomographic plane divided by the product of the nominal tomographic section thickness and the number of tomograms produced in a single scan, that is:

$$CTDI = \frac{1}{nT} \int_{-7T}^{+7T} D(z) dz$$

where:

- z = Position along a line perpendicular to the tomographic plane.
- $D(z)$ = Dose at position z .
- T = Nominal tomographic section thickness.
- n = Number of tomograms produced in a single scan.

This definition assumes that the dose profile is centered around $z = 0$ and that, for a multiple tomogram system, the scan increment between adjacent scans is nT .

“*Contrast scale*” means the change in the linear attenuation coefficient per CTN relative to water, that is:

$$CS = \frac{\mu_x - \mu_w}{(CTN)_x - (CTN)_w}$$

where:

μ_x = Linear attenuation coefficient of the material of interest.

μ_w = Linear attenuation coefficient of water.

$(CTN)_x$ = CTN of the material of interest.

$(CTN)_w$ = CTN of water.

“CS” (see “Contrast scale”).

“*CT conditions of operation*” means all selectable parameters governing the operation of a CT X-ray system including, but not limited to, nominal tomographic section thickness, filtration, and the technique factors as defined in 41.1(2).

“*CTDI*” (see “Computed tomography dose index”).

“*CT gantry*” means the tube housing assemblies, beam-limiting devices, detectors, and the supporting structures and frames which hold these components.

“*CTN*” (see “CT number”).

“*CT number*” means the number used to represent the X-ray attenuation associated with each elemental area of the CT image.

$$CTN = \frac{k(\mu_x - \mu_w)}{\mu_w}$$

where:

k = A constant. (The constant has a normal value of 1,000 when the Hounsfield scale of CTN is used.)

μ_x = Linear attenuation coefficient of the material of interest.

μ_w = Linear attenuation coefficient of water.

“*Dose profile*” means the dose as a function of position along a line.

“*Elemental area*” means the smallest area within a tomogram for which the X-ray attenuation properties of a body are depicted (see also “Picture element”).

“*Multiple tomogram system*” means a computed tomography X-ray system which obtains X-ray transmission data simultaneously during a single scan to produce more than one tomogram.

“*Noise*” means the standard deviation of the fluctuations in CTN expressed as a percentage of the attenuation coefficient of water. Its estimate (S_n) is calculated using the following expression:

$$S_n = \frac{100 \times CS \times s}{m_w}$$

where:

CS = Linear attenuation coefficient of the material of interest.

m_w = Linear attenuation coefficient of water.

s = Estimated standard deviation of the CTN of picture elements in a specified area of the CT image.

“*Nominal tomographic section thickness*” means the full width at half-maximum of the sensitivity profile taken at the center of the cross-sectional volume over which X-ray transmission data are collected.

“Picture element” means an elemental area of a tomogram.

“Reference plane” means a plane which is displaced from and parallel to the tomographic plane.

“Scan” means the complete process of collecting X-ray transmission data for the production of a tomogram. Data can be collected simultaneously during a single scan for the production of one or more tomograms.

“Scan increment” means the amount of relative displacement of the patient with respect to the CT X-ray system between successive scans measured along the direction of such displacement.

“Scan sequence” means a preselected set of two or more scans performed consecutively under pre-selected CT conditions of operation.

“Scan time” means the period of time between the beginning and end of X-ray transmission data accumulation for a single scan.

“Single tomogram system” means a CT X-ray system which obtains X-ray transmission data during a scan to produce a single tomogram.

“Tomographic plane” means that geometric plane which is identified as corresponding to the output tomogram.

“Tomographic section” means the volume of an object whose X-ray attenuation properties are imaged in a tomogram.

b. Requirements for equipment.

(1) Termination of exposure.

1. Means shall be provided to terminate the X-ray exposure automatically by either deenergizing the X-ray source or shuttering the X-ray beam in the event of equipment failure affecting data collection. Such termination shall occur within an interval that limits the total scan time to no more than 110 percent of its preset value through the use of either a backup timer or devices which monitor equipment function.

2. A visible signal shall indicate when the X-ray exposure has been terminated through the means required by 41.1(11)“b”(1)“1.”

3. The operator shall be able to terminate the X-ray exposure at any time during a scan, or series of scans under CT X-ray system control, of greater than one-half second duration.

(2) Tomographic plane indication and alignment.

1. For any single tomogram system, means shall be provided to permit visual determination of the tomographic plane or a reference plane offset from the tomographic plane.

2. For any multiple tomogram system, means shall be provided to permit visual determination of the location of a reference plane. This reference plane can be offset from the location of the tomographic planes.

3. If a device using a light source is used to satisfy 41.1(11)“b”(2)“1” or “2,” the light source shall provide illumination levels sufficient to permit visual determination of the location of the tomographic plane or reference plane under ambient light conditions of up to 500 lux.

(3) Beam-on and shutter status indicators and control switches.

1. The CT X-ray control and gantry shall provide visual indication whenever X-rays are produced and, if applicable, whether the shutter is open or closed.

2. Each emergency button or switch shall be clearly labeled as to its function.

(4) Indication of CT conditions of operation. The CT X-ray system shall be designed such that the CT conditions of operation to be used during a scan or a scan sequence shall be indicated prior to the initiation of a scan or a scan sequence. On equipment having all or some of these conditions of operation at fixed values, this requirement may be met by permanent markings. Indication of CT conditions of operation shall be visible from any position from which scan initiation is possible.

(5) Extraneous radiation. When data are not being collected for image production, the radiation adjacent to the tube port shall not exceed that permitted by 41.1(4)“c.”

(6) Maximum surface CTDI identification. The angular position where the maximum surface CTDI occurs shall be identified to allow for reproducible positioning of a CT dosimetry phantom.

(7) Additional requirements applicable to CT X-ray systems containing a gantry manufactured after September 3, 1985.

1. The total error in the indicated location of the tomographic plane or reference plane shall not exceed 5 millimeters.

2. If the X-ray production period is less than one-half second, the indication of X-ray production shall be actuated for at least one-half second. Indicators at or near the gantry shall be discernible from any point external to the patient opening where insertion of any part of the human body into the primary beam is possible.

3. The deviation of indicated scan increment versus actual increment shall not exceed plus or minus 1 millimeter with any mass from 0 to 100 kilograms resting on the support device. The patient support device shall be incremented from a typical starting position to the maximum incremented distance or 30 centimeters, whichever is less, and then returned to the starting position. Measurement of actual versus indicated scan increment may be taken anywhere along this travel.

4. Premature termination of the X-ray exposure by the operator shall necessitate resetting of the CT conditions of operation prior to the initiation of another scan.

c. Facility design requirements.

(1) Aural communication. Provision shall be made for two-way aural communication between the patient and the operator at the control panel.

(2) Viewing systems.

1. Windows, mirrors, closed-circuit television, or an equivalent shall be provided to permit continuous observation of the patient during irradiation and shall be so located that the operator can observe the patient from the control panel.

2. When the primary viewing system is by electronic means, an alternate viewing system (which may be electronic) shall be available for use in the event of failure of the primary viewing system.

d. Surveys, calibrations, spot checks, and operating procedures.

(1) Surveys.

1. All CT X-ray systems installed after the effective date of these rules and those systems not previously surveyed shall have a survey made by, or under the direction of, a qualified expert. In addition, such surveys shall be done after any change in the facility or equipment which might cause a significant increase in radiation hazard.

2. The registrant shall obtain a written report of the survey from the qualified expert, and a copy of the report shall be made available to the agency upon request.

(2) Radiation calibrations.

1. The calibration of the radiation output of the CT X-ray system shall be performed by, or under the direction of, a qualified expert who is physically present at the facility during such calibration.

2. The calibration of a CT X-ray system shall be performed at intervals specified by a qualified expert and after any change or replacement of components which, in the opinion of the qualified expert, could cause a change in the radiation output.

3. The calibration of the radiation output of a CT X-ray system shall be performed with a calibrated dosimetry system. The calibration of such system shall be traceable to a national standard. The dosimetry system shall have been calibrated within the preceding two years.

4. CT dosimetry phantom(s) shall be used in determining the radiation output of a CT X-ray system. Such phantom(s) shall meet the following specifications and conditions of use: CT dosimetry phantom(s) shall be right circular cylinders of polymethyl methacrylate of density 1.19 plus or minus 0.01 grams per cubic centimeter. The phantom(s) shall be at least 14 centimeters in length and shall have diameters of 32.0 centimeters for testing CT X-ray systems designed to image any section of the body and 16.0 centimeters for systems designed to image the head or for whole body scanners operated in the head scanning mode; CT dosimetry phantom(s) shall provide means for the placement of a dosimeter(s) along the axis of rotation and along a line parallel to the axis of rotation 1.0 centimeter from the outer surface and within the phantom. Means for the placement of dosimeters or alignment devices at other locations may be provided; any effects on the doses measured due to the removal of phantom material to accommodate dosimeters shall be accounted for through appropriate corrections to the reported data or included in the statement of maximum deviation for the values obtained using the phantom; and all dose measurements shall be performed with the CT dosimetry phantom placed on the patient couch or support device without additional attenuation materials present.

5. The calibration shall be required for each type of head, body, or whole-body scan performed at the facility.

6. Calibration shall meet the following requirements: The dose profile along the center axis of the CT dosimetry phantom for the minimum, maximum, and midrange values of the nominal tomographic section thickness used by the registrant shall be measurable. Where less than three nominal tomographic thicknesses can be selected, the dose profile determination shall be performed for each available nominal tomographic section thickness; the CTDI along the two axes specified in 41.1(11)“d”(2)“4” shall be measured. (For the purpose of determining the CTDI, the manufacturer’s statement as to the nominal tomographic section thickness for that particular system may be utilized.) The CT dosimetry phantom shall be oriented so that the measurement point 1.0 centimeter from the outer surface and within the phantom is in the same angular position within the gantry as the point of maximum surface CTDI identified. The CT conditions of operation shall correspond to typical values used by the registrant; and the spot checks specified in 41.1(11)“d”(3) shall be made.

7. Calibration procedures shall be in writing. Records of calibrations performed shall be maintained for inspection by the agency.

(3) Spot checks.

1. The spot-check procedures shall be in writing and shall have been developed by a qualified expert.

2. The spot-check procedures shall incorporate the use of a CT dosimetry phantom which has a capability of providing an indication of contrast scale, noise, nominal tomographic section thickness, the resolution capability of the system for low and high contrast objects, and measuring the mean CTN for water or other reference material.

3. All spot checks shall be included in the calibration required by 41.1(11)“d”(2) and at time intervals and under system conditions specified by a qualified expert.

4. Spot checks shall include acquisition of images obtained with the CT dosimetry phantom(s) using the same processing mode and CT conditions of operation as are used to perform calibrations required by 41.1(11)“d”(2). The images shall be retained, until a new calibration is performed, in two forms as follows: photographic copies of the images obtained from the image display device; and images stored in digital form on a storage medium compatible with the CT X-ray system.

5. Written records of the spot checks performed shall be maintained for inspection by the agency.

(4) Operating procedures.

1. The CT X-ray system shall not be operated except by an individual who has been specifically trained in its operation.

2. Information shall be available at the control panel regarding the operation and calibration of the system. Such information shall include the following: dates of the latest calibration and spot checks and the location within the facility where the results of those tests may be obtained; instructions on the use of the CT dosimetry phantom(s) including a schedule of spot checks appropriate for the system, allowable variations for the indicated parameters, and the results of at least the most recent spot checks conducted on the system; the distance in millimeters between the tomographic plane and the reference plane if a reference plane is utilized; and a current technique chart available at the control panel which specifies for each routine examination the CT conditions of operation and the number of scans per examination.

3. If the calibration or spot check of the CT X-ray system identifies that a system operating parameter has exceeded a tolerance established by the qualified expert, use of the CT X-ray system on patients shall be limited to those uses permitted by established written instructions of the qualified expert.

41.1(12) *X-ray machines used for mammography.* Rescinded IAB 4/8/98, effective 7/1/98.

641—41.2(136C) Use of radionuclides in the healing arts.

41.2(1) *Purpose and scope.* This rule establishes requirements and provisions for the use of radionuclides in the healing arts and for issuance of licenses authorizing the medical use of this material. These requirements and provisions provide for the protection of the public health and safety. The requirements and provisions of this rule are in addition to, and not in substitution for, the applicable portions of 641—Chapters 38 to 40. The requirements and provisions of these rules apply to applicants and licensees subject to this rule unless specifically exempted. All references to any Code of Federal Regulations (CFR) in this chapter are those in effect as of July 1, 1998.

41.2(2) *Definitions.* For the purpose of this chapter, the definitions of 641—Chapters 38 to 40 may also apply. As used in 41.2(136C), the following definitions apply:

“*Area of use*” means a portion of a physical structure that has been set aside for the purpose of receiving, using, or storing radioactive material.

“*Authorized nuclear pharmacist*” means a pharmacist who has met the appropriate requirements of 41.2(78) and who is practicing nuclear pharmacy as authorized by a current Iowa radioactive materials license.

“*Authorized user*” means a physician, dentist, or podiatrist who has met the appropriate requirements of 41.2(67), 41.2(68), 41.2(69), 41.2(70), 41.2(71), 41.2(72), or 41.2(73) and who uses radioactive materials as authorized by a current medical use Iowa radioactive materials license.

“*Dedicated check source*” means a radioactive source that is used to ensure the constant operation of a radiation detection or measurement device over several months or years. This source may also be used for other purposes.

“*Management*” means the chief executive officer or that individual’s designee.

“*Medical institution*” means an organization in which several medical disciplines are practiced.

“*Mobile nuclear medicine service*” means the transportation and medical use of radioactive material.

“*Output*” means the exposure rate, dose rate, or a quantity related in a known manner to these rates from a teletherapy unit for a specified set of exposure conditions.

“Pharmacist” means an individual licensed by a state or territory of the United States, the District of Columbia, or the Commonwealth of Puerto Rico to practice pharmacy.

“Teletherapy physicist” means an individual identified as the qualified teletherapy physicist on an agency license.

“Visiting authorized user” means an authorized user who is not identified on the license of the licensee being visited.

41.2(3) License required.

a. No person shall manufacture, produce, acquire, receive, possess, use, or transfer radioactive material for medical use except in accordance with a specific license issued pursuant to these rules.

b. Unless prohibited by license condition, an individual may receive, possess, use, or transfer radioactive material in accordance with these rules under the supervision of an authorized user as provided in 41.2(11).

c. An individual may prepare unsealed radioactive material for medical use in accordance with these rules under the supervision of an authorized nuclear pharmacist or authorized user as provided in 41.2(11) unless prohibited by license condition.

d. A licensee may conduct research involving human subjects using radioactive material provided that the research is conducted, funded, supported, or regulated by another federal agency which has implemented the Federal Policy for the Protection of Human Subjects. Otherwise, a licensee shall apply for and receive approval of a specific amendment to its license before conducting such research. Both types of licensees shall, at a minimum, obtain informed consent from the human subjects and obtain prior review and approval of the research activities by an Institutional Review Board in accordance with the meaning of these terms as defined and described in the Federal Policy for the Protection of Human Subjects.

Nothing in this subrule relieves the licensee from complying with applicable FDA, federal, and other state requirements governing radioactive drugs or devices.

e. An applicant that satisfies the requirements of 641—paragraph 39.4(28)“b” may apply for a Type A specific license of broad scope.

41.2(4) License amendments. A licensee shall apply for and receive a license amendment:

a. Before using radioactive material for a method or type of medical use not permitted by the license issued under this rule;

b. Before permitting anyone, except a visiting authorized user described in 41.2(12), to work as an authorized user or authorized nuclear pharmacist under the license;

c. Before changing a radiation safety officer or teletherapy physicist;

d. Before receiving radioactive material in excess of the amount authorized on the license;

e. Before adding to or changing the areas of use or address or addresses of use identified in the application or on the license; and

f. Before changing statements, representations, and procedures which are incorporated into the license.

41.2(5) Notifications.

a. A licensee shall provide to the agency a copy of the board certification, the NRC or Agreement State license, or the permit issued by a licensee of broad scope for each individual no later than 30 days after the date that the licensee permits the individual to work as an authorized user or an authorized nuclear pharmacist pursuant to 41.2(4)“b”(1) to 41.2(4)“b”(4).

b. A licensee shall notify the agency by letter no later than 30 days after:

(1) An authorized user, an authorized nuclear pharmacist, radiation safety officer, or teletherapy physicist permanently discontinues performance of duties under the license or has a name change; or

(2) The licensee’s mailing address changes.

c. The licensee shall mail the documents required in this subrule to the Iowa Department of Public Health, Des Moines, Iowa.

d. Exemptions regarding Type A specific licenses of broad scope. A licensee possessing a Type A specific license of broad scope for medical use is exempt from the following:

- (1) The provision of 41.2(4) "b";
- (2) The provisions of 41.2(4) "e" regarding additions to or changes in the areas of use only at the addresses specified in the license;
- (3) The provision of 41.2(5) "a";
- (4) The provisions of 41.2(5) "b"(1) for authorized user or an authorized nuclear pharmacist.

41.2(6) Maintenance of records.

a. Each record required by this rule must be legible throughout the retention period specified by each subrule. The record may be original or reproduced copy or a microform, provided that the copy or microform is authenticated by authorized personnel and that the microform is capable of producing a clear copy throughout the required retention period.

b. The record may also be stored on electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records such as letters, drawings, and specifications must include all pertinent information such as stamps, initials, and signatures.

c. The licensee shall maintain adequate safeguards against tampering with and loss of records specified in 41.2(6) "a" and "b."

41.2(7) ALARA program.

a. Each licensee shall develop and implement a written program to maintain radiation doses and releases of radioactive material in effluents to unrestricted areas as low as reasonably achievable in accordance with 641—subrule 40.1(3).

b. To satisfy the requirement of 41.2(7) "a":

(1) The management, radiation safety officer, and all authorized users shall participate in the establishment, implementation, and operation of the program as required by these rules or the radiation safety committee; or

(2) For licensees that are not medical institutions, management and all authorized users shall participate in the program as required by the radiation safety officer.

c. The ALARA program shall include an annual review by the radiation safety committee for licensees that are medical institutions, or management and the radiation safety officer for licensees that are not medical institutions, of summaries of the types and amounts of radioactive material used, occupational dose reports, and continuing education and training for all personnel who work with or in the vicinity of radioactive material. The purpose of the review is to ensure that individuals make every reasonable effort to maintain occupational doses, doses to the general public, and releases of radioactive material as low as reasonably achievable, taking into account the state of technology, and the cost of improvements in relation to benefits.

d. The licensee shall retain a current written description of the ALARA program for the duration of the license. The written description shall include:

(1) A commitment by management to keep occupational doses as low as reasonably achievable;

(2) A requirement that the radiation safety officer brief management once each year on the radiation safety program;

(3) Personnel exposure investigational levels as established in accordance with 41.2(9) "b"(8) that, when exceeded, will initiate an investigation by the radiation safety officer of the cause of the exposure; and

(4) Personnel exposure investigational levels that, when exceeded, will initiate a prompt investigation by the radiation safety officer of the cause of the exposure and a consideration of actions that might be taken to reduce the probability of recurrence.

41.2(8) Radiation safety officer.

a. A licensee shall appoint a radiation safety officer responsible for implementing the radiation safety program. The licensee, through the radiation safety officer, shall ensure that radiation safety activities are being performed in accordance with approved procedures and regulatory requirements in the daily operation of the licensee's radioactive material program.

b. The radiation safety officer shall:

(1) Investigate overexposures, accidents, spills, losses, thefts, unauthorized receipts, uses, transfers, and disposals, and other deviations from approved radiation safety practice and implement corrective actions as necessary;

(2) Implement written policy and procedures for:

1. Authorizing the purchase of radioactive material;
2. Receiving and opening packages of radioactive material;
3. Storing radioactive material;
4. Keeping an inventory record of radioactive material;
5. Using radioactive material safely;
6. Taking emergency action if control of radioactive material is lost;
7. Performing periodic radiation surveys;
8. Performing checks and calibrations of survey instruments and other safety equipment;
9. Disposing of radioactive material;
10. Training personnel who work in or frequent areas where radioactive material is used or stored;

and
11. Keeping a copy of all records and reports required by the agency rules, a copy of these rules, a copy of each licensing request and license and amendments, and the written policy and procedures required by the rules; and

(3) For medical use not sited at a medical institution, approve or disapprove radiation safety program changes with the advice and consent of management prior to submittal to the agency for licensing action; or

(4) For medical use sited at a medical institution, assist the radiation safety committee in the performance of its duties.

41.2(9) Radiation safety committee. Each medical institution licensee shall establish a radiation safety committee to oversee the use of radioactive material.

a. The committee shall meet the following administrative requirements:

(1) Membership must consist of at least three individuals and shall include an authorized user of each type of use permitted by the license, the radiation safety officer, a representative of the nursing service, and a representative of management who is neither an authorized user nor a radiation safety officer. Other members may be included as the licensee deems appropriate.

(2) The committee shall meet at least once each calendar quarter.

(3) To establish a quorum and to conduct business, one-half of the committee's membership shall be present, including the radiation safety officer and the management's representative.

(4) The minutes of each radiation safety committee meeting shall include:

1. The date of the meeting;
2. Members present;
3. Members absent;
4. Summary of deliberations and discussions;

5. Recommended actions and the numerical results of all ballots; and
 6. Document any reviews required in 41.2(7)“c” and 41.2(9)“b.”
- (5) The committee shall provide each member with a copy of the meeting minutes and retain one copy until the agency authorizes its disposition.
- b.* To oversee the use of licensed material, the committee shall:
- (1) Be responsible for monitoring the institutional program to maintain occupational doses as low as reasonably achievable;
 - (2) Review:
 1. Review, on the basis of safety and with regard to the training and experience standards of this rule, and approve or disapprove any individual who is to be listed as an authorized user, an authorized nuclear pharmacist, the radiation safety officer, or teletherapy physicist before submitting a license application or request for amendment or renewal;
 2. Review, pursuant to 41.2(4)“b”(1) to 41.2(4)“b”(4), on the basis of the board certification, the license, or the permit identifying an individual, and approve or disapprove any individual prior to allowing that individual to work as an authorized user or authorized nuclear pharmacist.
 - (3) Review on the basis of safety and approve or disapprove each proposed method of use of radioactive material;
 - (4) Review on the basis of safety, and approve with the advice and consent of the radiation safety officer and the management representative, or disapprove procedures and radiation safety program changes prior to submittal to the agency for licensing action;
 - (5) Review quarterly, with the assistance of the radiation safety officer, occupational radiation exposure records of all personnel working with radioactive material;
 - (6) Review quarterly, with the assistance of the radiation safety officer, all incidents involving radioactive material with respect to cause and subsequent actions taken;
 - (7) Review annually, with the assistance of the radiation safety officer, the radioactive material program; and
 - (8) Establish a table of investigational levels for occupational dose that, when exceeded, will initiate investigations and considerations of action by the radiation safety officer.
- 41.2(10) *Statement of authorities and responsibilities.***
- a.* A licensee shall provide sufficient authority and organizational freedom to the radiation safety officer and the radiation safety committee to:
- (1) Identify radiation safety problems;
 - (2) Initiate, recommend, or provide solutions; and
 - (3) Verify implementation of corrective actions.
- b.* A licensee shall establish in writing the authorities, duties, responsibilities, and radiation safety activities of the radiation safety officer and the radiation safety committee.
- 41.2(11) *Supervision.***
- a.* A licensee who permits the receipt, possession, use, or transfer of radioactive material by an individual under the supervision of an authorized user as allowed by 41.2(3) shall:
- (1) Instruct the supervised individual in the principles of radiation safety appropriate to that individual’s use of radioactive material;
 - (2) Review the supervised individual’s use of radioactive material, provide reinstruction as needed and review records kept to reflect this use;
 - (3) Require the authorized user to be immediately available to communicate with the supervised individual;

(4) Require the authorized user to be able to be physically present and available to the supervised individual on one hour's notice (the supervising authorized user need not be present for each use of radioactive material); and

(5) Require that only those individuals specifically trained, and designated by the authorized user, shall be permitted to administer radionuclides or radiation to patients or human research subjects.

b. A license shall require the supervised individual receiving, possessing, using or transferring radioactive material under 41.2(3) to:

- (1) Follow the instructions of the supervising authorized user;
- (2) Follow the procedures established by the radiation safety officer; and
- (3) Comply with these rules and the license conditions with respect to the use of radioactive material.

c. A licensee that permits the preparation of radioactive material for medical use by an individual under the supervision of an authorized nuclear pharmacist or physician who is an authorized user, as allowed by 41.2(3) "c," shall:

(1) Instruct the supervised individual in the preparation of radioactive material for medical use and the principles of and procedures for radiation safety and in the licensee's written quality management program, as appropriate to that individual's use of radioactive material;

(2) Require the supervised individual to follow the instructions given pursuant to 41.2(11) "c" and to comply with the regulations of this chapter and license conditions; and

(3) Require the supervising authorized nuclear pharmacist or physician who is an authorized user to periodically review the work of the supervised individual as it pertains to preparing radioactive material for medical use and the records kept to reflect that work.

d. A licensee that supervises an individual is responsible for the acts and omissions of the supervised individual.

41.2(12) *Visiting authorized user.*

a. A licensee may permit any visiting authorized user to use licensed material for medical use under the terms of the licensee's license for 60 days each year if:

(1) The visiting authorized user has the prior written permission of the licensee's management and, if the use occurs on behalf of an institution, the institution's radiation safety committee;

(2) The licensee has a copy of an agency, agreement state, licensing state or U.S. Nuclear Regulatory Commission license that identifies the visiting authorized user by name as an authorized user for medical use; and

(3) Only those procedures for which the visiting authorized user is specifically authorized by an agency [, agreement state, licensing state or U.S. Nuclear Regulatory Commission] license are performed by that individual.

b. A licensee need not apply for a license amendment in order to permit a visiting authorized user to use licensed material as described in 41.2(12) "a."

c. A licensee shall retain copies of the records specified in 41.2(12) "a" for five years from the date of the last visit.

41.2(13) *Mobile nuclear medicine service administrative requirements.*

a. The agency will only license mobile nuclear medicine services in accordance with this rule and other applicable requirements of these rules.

b. Mobile nuclear medicine service licensees shall retain for the duration of service a letter signed by the management of each location where services are rendered that authorizes use of radioactive material.

c. If a mobile nuclear medicine service provides services that the client is also authorized to provide, the client is responsible for ensuring that services are conducted in accordance with the rules in this chapter while the mobile nuclear medicine service is under the client's direction.

d. A mobile nuclear medicine service shall not have radioactive material delivered directly from the manufacturer or the distributor to the client's address of use.

41.2(14) *Records and reports of misadministrations.*

a. When a misadministration involves any therapy procedure, the licensee shall notify the agency by telephone. The licensee shall also notify the referring physician of the affected patient or human research subject and the patient or human research subject or a responsible relative or guardian, unless the referring physician agrees to inform the patient or human research subject or believes, based on medical judgment, that telling the patient or human research subject or the patient's or human research subject's responsible relative or guardian would be harmful to one or the other, respectively. These notifications must be made within 24 hours after the licensee discovers the misadministration. If the referring physician, patient or human research subject, or the patient's or human research subject's responsible relative or guardian cannot be reached within 24 hours, the licensee shall notify them as soon as practicable. The licensee is not required to notify the patient or human research subject or the patient's or human research subject's responsible relative or guardian without first consulting the referring physician; however, the licensee shall not delay medical care for the patient or human research subject because of this including remedial care as a result of the misadministration because of any delay in notification.

b. Written reports.

(1) The licensee shall submit a written report to the agency within 15 days after discovery of the misadministration. The written report must include the licensee's name, the prescribing physician's name, a brief description of the event, why the event occurred, the effect on the patient or the human research subject, what improvements are needed to prevent recurrence, actions taken to prevent recurrence, whether the licensee notified the patient or the human research subject or the patient's or the human research subject's responsible relative or guardian (this individual will subsequently be referred to as "the patient or the human research subject"), and if not, why not, and if the patient or the human research subject was notified, what information was provided to that individual. The report must not include the patient's or the human research subject's name or other information that could lead to identification of the patient or the human research subject.

(2) If the patient or the human research subject was notified, the licensee shall also furnish, within 15 days after discovery of the misadministration, a written report to the patient or the human research subject by sending either:

1. A copy of the report that was submitted to the agency; or
2. A brief description of both the event and the consequences as they may affect the patient or the human research subject, provided a statement is included that the report submitted to the agency can be obtained from the licensee.

c. When a misadministration involves a diagnostic procedure, the radiation safety officer shall promptly investigate its cause, make a record for agency review, and retain the record as directed in 41.2(14) "d." The licensee shall also notify the referring physician and the agency in writing on IDPH Form #588-2608 within 15 days if the misadministration involved the use of radioactive material not intended for medical use, administration of dosage five-fold different from the intended dosage, or administration of radioactive material such that the patient or human research subject is likely to receive an organ dose greater than 2 rems (0.02 Sv) or a whole body dose greater than 500 millirems (5 mSv). Licensees may use dosimetry tables in package inserts, corrected only for amount of radioactivity administered, to determine whether a report is required.

d. Each licensee shall retain a record of each misadministration for ten years. The record shall contain the names of all individuals involved in the event, including the physician, allied health personnel, the patient or human research subject, and the patient's or human research subject's referring physician, the patient's or human research subject's social security number or identification number if one has been assigned, a brief description of the event, why it occurred, the effect on the patient or human research subject, what improvements are needed to prevent recurrence, and the action taken, if any, to prevent recurrence.

e. Aside from the notification requirement, nothing in 41.2(14) "a" to 41.2(14) "d" shall affect any rights or duties of licensees and physicians in relation to each other, patients or human research subjects, or responsible relatives or guardians.

f. Written directives. Each licensee shall meet the following objectives:

(1) That, prior to administration, a written directive¹ is prepared for:

1. Any teletherapy radiation dose;
2. Any gamma stereotactic radiosurgery radiation dose;
3. Any brachytherapy radiation dose;
4. Any administration of quantities greater than 30 microcuries of either sodium iodide I-125 or I-131; or

5. Any therapeutic administration of a radiopharmaceutical, other than sodium iodide I-125 or I-131;

(2) That, prior to each administration, the patient's or human research subject's identity is verified by more than one method as the individual named in the written directive;

(3) That final plans of treatment and related calculations for brachytherapy, teletherapy, and gamma stereotactic radiosurgery are in accordance with the respective written directives;

(4) That each administration is in accordance with the written directive; and

(5) That any unintended deviation from the written directive is identified and evaluated, and appropriate action is taken.

(6) The licensee shall retain:

1. Each written directive; and

2. A record of each administered radiation dose or radiopharmaceutical dosage where a written directive is required in 41.2(14) "f"(1) in an auditable form, for three years after the date of administration.

¹If, because of the patient's condition, a delay in order to provide a written revision to an existing written directive would jeopardize the patient's health, an oral revision to an existing written directive will be acceptable, provided that the oral revision is documented immediately in the patient's record and a revised written directive is signed by the authorized user within 48 hours of the oral revision.

Also, a written revision to an existing written directive may be made for any diagnostic or therapeutic procedure provided that the revision is dated and signed by an authorized user prior to the administration of the radiopharmaceutical dosage, the brachytherapy dose, the gamma stereotactic radiosurgery dose, the teletherapy dose, or the next teletherapy fractional dose.

If, because of the emergent nature of the patient's condition, a delay in order to provide a written directive would jeopardize the patient's health, an oral directive will be acceptable, provided that the information contained in the oral directive is documented immediately in the patient's record and a written directive is prepared within 24 hours of the oral directive.

41.2(15) Suppliers. A licensee shall use for medical use only:

- a. Radioactive material manufactured, labeled, packaged, and distributed in accordance with a license issued pursuant to these rules or the equivalent regulations of another agreement state, a licensing state or the U.S. Nuclear Regulatory Commission; and
- b. Reagent kits that have been manufactured, labeled, packaged, and distributed in accordance with an approval issued by the U.S. Food and Drug Administration;
- c. Teletherapy sources manufactured and distributed in accordance with a license issued pursuant to these rules, or the equivalent regulations of another agreement state, a licensing state, or the U.S. Nuclear Regulatory Commission.

41.2(16) Quality control of imaging equipment. Each licensee shall establish written quality control procedures for all equipment used to obtain images from radionuclide studies. As a minimum, the procedures shall include quality control procedures recommended by equipment manufacturers or procedures which have been approved by the agency. The licensee shall conduct quality control procedures in accordance with written procedures.

41.2(17) Possession, use, calibration, and check of dose calibrators.

a. A medical use licensee authorized to administer radiopharmaceuticals shall possess a dose calibrator and use it to measure the amount of activity administered to each patient or human research subject.

b. A licensee shall:

(1) Check each dose calibrator for constancy with a dedicated check source at the beginning of each day of use. To satisfy the requirement of this section, the check shall be done on a frequently used setting with a sealed source of not less than 10 microcuries (370 kBq) of radium-226 or 50 microcuries (1.85 MBq) of any other photon-emitting radionuclide with a half-life greater than 90 days;

(2) Test each dose calibrator for accuracy upon installation and at intervals not to exceed 12 months thereafter by assaying at least two sealed sources containing different radionuclides, the activity of which the manufacturer has determined within 5 percent of the stated activity, with minimum activity of 10 microcuries (370 kBq) for radium-226 and 50 microcuries (1.85 MBq) for any other photon-emitting radionuclide, and at least one of which has a principal photon energy between 100 keV and 500 keV;

(3) Test each dose calibrator for linearity upon installation and at intervals not to exceed three months thereafter over the range of use between 30 microcuries (1.1 megabecquerels) and the highest dosage that will be administered; and

(4) Test each dose calibrator for geometry dependence upon installation over the range of volumes and volume configurations for which it will be used. The licensee shall keep a record of this test for the duration of the use of the dose calibrator.

c. A licensee shall mathematically correct dosage readings for any geometry or linearity error that exceeds 10 percent if the dosage is greater than 10 microcuries (370 kBq) and shall repair or replace the dose calibrator if the accuracy or constancy error exceeds 10 percent.

d. A licensee shall also perform checks and tests required by 41.2(17) "b" following adjustment or repair of the dose calibrator.

e. A licensee shall retain a record of each check and test required by 41.2(17) for three years. The records required by 41.2(17) "b" shall include:

(1) For 41.2(17) "b" (1), the model and serial number of the dose calibrator, the identity and calibrated activity of the radionuclide contained in the check source, the date of the check, the activity measured, the instrument settings, and the initials of the individual who performed the check;

(2) For 41.2(17) "b" (2), the model and serial number of the dose calibrator, the model and serial number of each source used and the identity of the radionuclide contained in the source and its activity, the date of the test, the results of the test, the instrument settings, the identity of the individual performing the test, and the signature of the radiation safety officer;

(3) For 41.2(17)“b”(3), the model and serial number of the dose calibrator, the calculated activities, the measured activities, the date of the test, the identity of the individual performing the test, and the signature of the radiation safety officer; and

(4) For 41.2(17)“b”(4), the model and serial number of the dose calibrator, the configuration calibrated activity of the source measured, the activity of the source, the activity measured and the instrument setting for each volume measured, the date of the test, the identity of the individual performing the test, and the signature of the radiation safety officer.

41.2(18) Calibration and check of survey instruments.

a. A licensee shall ensure that the survey instruments used to show compliance with this rule have been calibrated before first use, annually, and following repair.

b. To satisfy the requirements of 41.2(18)“a,” the licensee shall:

(1) Calibrate all required scale readings up to 1000 millirems (10 mSv) per hour with a radiation source;

(2) For each scale that shall be calibrated, calibrate two readings separated by at least 50 percent of scale rating; and

(3) Conspicuously note on the instrument the apparent dose rate from a dedicated check source as determined at the time of calibration, and the date of calibration.

c. To satisfy the requirements of 41.2(18)“b,” the licensee shall consider a point as calibrated if the indicated exposure rate differs from the calculated exposure rate by not more than 20 percent and shall conspicuously attach a correction chart or graph to the instrument.

d. A licensee shall check each survey instrument for proper operation with the dedicated check source before each use. The licensee is not required to keep records of these checks.

e. The licensee shall retain a record of each calibration required in 41.2(18)“a” for three years. The record shall include:

(1) A description of the calibration procedure; and

(2) A description of the source used and the certified dose rates from the source, the rates indicated by the instrument being calibrated, the correction factors deduced from the calibration data, the signature of the individual who performed the calibration, and the date of calibration.

f. To meet the requirements of 41.2(18)“a,” “b,” and “c,” the licensee may obtain the services of individuals licensed by the agency, the U.S. Nuclear Regulatory Commission, an agreement state, or a licensing state to perform calibrations of survey instruments. Records of calibrations which contain information required by 41.2(18)“e” shall be maintained by the licensee.

g. Possession, use, calibration, and check of instruments to measure dosages of alpha- or beta-emitting radionuclides.

(1) This subrule does not apply to unit dosages of alpha- or beta-emitting radionuclides that are obtained from a manufacturer or preparer licensed pursuant to 641—paragraph 39.4(29)“j,” the U.S. Nuclear Regulatory Commission or equivalent Agreement State requirements.

(2) For other than unit dosages obtained pursuant to 41.2(18)“g”(1) a licensee shall possess and use instrumentation to measure the radioactivity of alpha- or beta-emitting radionuclides. The licensee shall have procedures for use of the instrumentation. The licensee shall measure, by direct measurement or by combination of measurements and calculations, the amount of radioactivity in dosages of alpha- or beta-emitting radionuclides prior to administration to each patient or human research subject. In addition, the licensee shall:

1. Perform tests before initial use, periodically, and following repair, on each instrument for accuracy, linearity, and geometry dependence, as appropriate for the use of the instrument, and make adjustments when necessary; and

2. Check each instrument for constancy and proper operation at the beginning of each day of use.

41.2(19) Assay of radiopharmaceutical dosages. A licensee shall:

- a. Assay, prior to medical use, the activity of each radiopharmaceutical dosage that contains more than 30 microcuries (1.1 megabecquerels) of a photon-emitting radionuclide;
- b. Assay, before medical use, the activity of each radiopharmaceutical dosage of a photon-emitting radionuclide to verify that the dosage does not exceed 30 microcuries (1.1 mBq); and
- c. Measure, by direct measurement or by combination of measurements and calculations, the activity of each dosage of an alpha- or beta-emitting radionuclide prior to medical use, except for unit dosages obtained from a manufacturer or preparer licensed pursuant to 641—paragraph 39.4(29) “j” or equivalent NRC or Agreement State requirements.
- d. Retain a record of the assays required by 41.2(19) “a” for three years. To satisfy this requirement, the record shall contain the:
 - (1) Generic name, trade name, or abbreviation of the radiopharmaceutical, its lot number, and expiration dates and the radionuclide;
 - (2) Patient’s or human research subject’s name and identification number if one has been assigned;
 - (3) Prescribed dosage and activity of the dosage at the time of assay, or a notation that the total activity is less than 30 microcuries (1.1 megabecquerels);
 - (4) Date and time of the assay and administration; and
 - (5) Initials of the individual who performed the assay.

41.2(20) Authorization for calibration and reference sources. Any person authorized by 41.2(3) for medical use of radioactive material may receive, possess, and use the following radioactive material for check, calibration and reference use:

- a. Sealed sources manufactured and distributed by persons specifically licensed pursuant to 641—Chapter 39 or equivalent provisions of the U.S. Nuclear Regulatory Commission, agreement state or licensing state and that do not exceed 15 millicuries (555 MBq) each;
- b. Any radioactive material listed in 41.2(31) or 41.2(33) with a half-life of 100 days or less in individual amounts not to exceed 15 millicuries (555 MBq);
- c. Any radioactive material listed in 41.2(31) or 41.2(33) with a half-life greater than 100 days in individual amounts not to exceed 200 microcuries (7.4 MBq) each; and
- d. Technetium-99m in individual amounts not to exceed 50 millicuries (1.85 GBq).

41.2(21) Requirements for possession of sealed sources and brachytherapy sources.

- a. A licensee in possession of any sealed source or brachytherapy source shall follow the radiation safety and handling instructions supplied by the manufacturer or equivalent instructions approved by the agency and shall maintain the instructions for the duration of source use in a legible form convenient to users.
- b. A licensee in possession of a sealed source shall ensure that:
 - (1) The source is tested for leakage before its first use unless the licensee has a certificate from the supplier indicating that the source was tested within six months before transfer to the licensee; and
 - (2) The source is tested for leakage at intervals not to exceed six months or at intervals approved by the agency, another agreement state, a licensing state or the U.S. Nuclear Regulatory Commission.
- c. To satisfy the leak test requirements of 41.2(21) “b,” the licensee shall ensure that:
 - (1) Leak tests are capable of detecting the presence of 0.005 microcurie (185 Bq) of radioactive material on the test sample or, in the case of radium, the escape of radon at the rate of 0.001 microcurie (37 Bq) per 24 hours;
 - (2) Test samples are taken from the source or from the surfaces of the device in which the source is mounted or stored on which radioactive contamination might be expected to accumulate; and
 - (3) Test samples are taken when the source is in the “off” position.

d. A licensee shall retain leak test records for five years. The records shall contain the model number, and serial number, if assigned, of each source tested, the identity of each source radionuclide and its estimated activity, the measured activity of each test sample expressed in microcuries (becquerels), a description of the method used to measure each test sample, the date of the test, and the signature of the radiation safety officer.

e. If the leak test reveals the presence of 0.005 microcurie (185 Bq) or more of removable contamination, the licensee shall:

(1) Immediately withdraw the sealed source from use and store it in accordance with the requirements of these rules; and

(2) File a report with the agency within five days of receiving the leak test results with the agency describing the equipment involved, the test results, and the action taken.

f. A licensee need not perform a leak test on the following sources:

(1) Sources containing only radioactive material with a half-life of less than 30 days;

(2) Sources containing only radioactive material as a gas;

(3) Sources containing 100 microcuries (3.7 MBq) or less of beta or photon-emitting material or 10 microcuries (370 kBq) or less of alpha-emitting material; [and]

(4) Seeds of iridium-192 encased in nylon ribbon; and

(5) Sources stored and not being used. The licensee shall, however, test each such source for leakage before any use or transfer unless it has been tested for leakage within six months before the date of use or transfer.

g. A licensee in possession of a sealed source or brachytherapy source shall conduct a physical inventory of all such sources at intervals not to exceed three months. The licensee shall retain each inventory record for five years. The inventory records shall contain the model number of each source, and serial number if one has been assigned, the identity of each source radionuclide and its estimated activity, the location of each source, date of the inventory, and the signature of the radiation safety officer.

h. A licensee in possession of a sealed source or brachytherapy source shall survey with a radiation survey instrument at intervals not to exceed three months all areas where such sources are stored. This does not apply to teletherapy sources in teletherapy units or sealed sources in diagnostic devices.

i. A licensee shall retain a record of each survey required in 41.2(21)“*h*” for three years. The record shall include the date of the survey, a sketch of each area that was surveyed, the measured dose rate at several points in each area expressed in millirems (microsieverts) per hour, the model number and serial number of the survey instrument used to make the survey, and the signature of the radiation safety officer.

41.2(22) *Syringe shields.*

a. A licensee shall keep syringes that contain radioactive material to be administered in a radiation shield.

b. A licensee shall require each individual who prepares or administers radiopharmaceuticals to use a syringe radiation shield unless the use of the shield is contraindicated for that patient or human research subject.

41.2(23) *Syringe labels.* Unless utilized immediately, a licensee shall conspicuously label each syringe, or syringe radiation shield that contains a syringe with a radiopharmaceutical, with the radiopharmaceutical name or its abbreviation, the type of diagnostic study or therapy procedure to be performed, or the patient's or human research subject's name.

41.2(24) *Vial shields.* A licensee shall require each individual preparing or handling a vial that contains a radiopharmaceutical to keep the vial in a vial radiation shield.

41.2(25) *Vial shield labels.* A licensee shall conspicuously label each vial radiation shield that contains a vial of a radiopharmaceutical with the radiopharmaceutical name or its abbreviation.

41.2(26) *Surveys for contamination and ambient radiation dose rate.*

a. A licensee shall survey with a radiation detection survey instrument at the end of each day of use all areas where radiopharmaceuticals are routinely prepared for use or administered.

b. A licensee shall survey with a radiation detection survey instrument at least once each week all areas where radiopharmaceuticals or radioactive wastes are stored.

c. A licensee shall conduct the surveys required by 41.2(26) "*a*" and "*b*" so as to be able to measure dose rates as low as 0.1 millirem ($1\ \mu\text{Sv}$) per hour.

d. A licensee shall establish dose rate action levels for the surveys required by 41.2(26) "*a*" and "*b*" and shall require that the individual performing the survey immediately notify the radiation safety officer if a dose rate exceeds an action level.

e. A licensee shall survey for removable contamination each day of use all areas where radiopharmaceuticals are routinely prepared for use or administered and each week where radioactive materials are stored.

f. A licensee shall conduct the surveys required by 41.2(26) "*e*" so as to be able to detect contamination on each wipe sample of 2000 disintegrations per minute (33.3 Bq).

g. A licensee shall establish removable contamination action levels for the surveys required by 41.2(26) "*e*" and shall require that the individual performing the survey immediately notify the radiation safety officer if contamination exceeds action levels.

h. A licensee shall retain a record of each survey required by 41.2(26) "*a*," "*b*," and "*e*" for two years. The record must include the date of the survey, a sketch of each area surveyed, action levels established for each area, the measured dose rate at several points in each area expressed in millirems (microsieverts) per hour or the removable contamination in each area expressed in disintegrations per minute (becquerels) per 100 square centimeters, the serial number and the model number of the instrument used to make the survey or analyze the samples, and the initials of the individual who performed the survey.

41.2(27) *Release of patients or human research subjects containing radiopharmaceuticals or permanent implants.*

a. A licensee shall not authorize release from confinement for medical care any patient or human research subject administered a radiopharmaceutical until either:

(1) The dose rate from the patient or human research subject is less than 5 millirems ($50\ \mu\text{Sv}$) per hour at a distance of 1 meter; or

(2) The activity in the patient or human research subject is less than 30 millicuries (1.11 GBq).

b. A licensee shall not authorize release from confinement for medical care any patient or human research subject administered a permanent implant until the dose rate from the patient or human research subject is less than 5 millirems ($50\ \text{mSv}$) per hour at a distance of 1 meter.

41.2(28) *Mobile nuclear medicine service technical requirements.* A licensee providing mobile nuclear medicine service shall:

a. Transport to each address of use only syringes or vials containing prepared radiopharmaceuticals or radiopharmaceuticals that are intended for reconstitution of radiopharmaceutical kits;

b. Bring into each location of use all radioactive material to be used and, before leaving, remove all unused radioactive material and associated radioactive waste;

c. Secure or keep under constant surveillance and immediate control all radioactive material when in transit or at a location of use;

d. Check survey instruments and dose calibrators as required in 41.2(17)“b”(1)“d” and “e” and 41.2(18)“d” and check all other transported equipment for proper function before medical use at each location of use;

e. Carry a calibrated survey meter in each vehicle that is being used to transport radioactive material and, before leaving a client location of use, survey all areas of radiopharmaceutical use with a radiation detection survey instrument to ensure that all radiopharmaceuticals and all associated radioactive waste have been removed; and

f. Retain a record of each survey required by 41.2(28)“e” for three years. The record must include the date of the survey, a plan of each area that was surveyed, the measured dose rate at several points in each area of use expressed in millirems (microsieverts) per hour, the model and serial number of the instrument used to make the survey, and the initials of the individual who performed the survey.

41.2(29) Storage of volatiles and gases.

a. A licensee shall store volatile radiopharmaceuticals and radioactive gases in the shippers' radiation shield and container.

b. A licensee shall store and use a multidose container in a properly functioning fume hood.

41.2(30) Decay-in-storage.

a. A licensee may hold radioactive material with half-lives of less than 65 days, except for Cobalt-57 for decay-in-storage before disposal in ordinary trash and is exempt from the requirements of 641—subrule 40.70(1) if the licensee:

(1) Holds radioactive material for decay a minimum of ten half-lives;

(2) Monitors radioactive material at the container surface before disposal as ordinary trash and determines that its radioactivity cannot be distinguished from the background radiation level with a radiation detection survey instrument set on its most sensitive scale and with no interposed shielding;

(3) Removes or obliterates all radiation labels; and

(4) Separates and monitors each generator column individually with all radiation shielding removed to ensure that its contents have decayed to background radiation level before disposal.

b. For radioactive material disposed in accordance with 41.2(30)“a,” the licensee shall retain a record of each disposal for three years. The record must include the date of the disposal, the date on which the radioactive material was placed in storage, the radionuclides disposed, the model and serial number of the survey instrument used, the background dose rate, the radiation dose rate measured at the surface of each waste container, and the name of the individual who performed the disposal.

41.2(31) Use of radiopharmaceuticals for uptake, dilution, or excretion studies. A licensee may use any radioactive material in a radiopharmaceutical for a diagnostic use involving measurements of uptake, dilution, or excretion for which the Food and Drug Administration (FDA) has a “Notice of Claimed Investigational Exemption for a New Drug” (IND) or approved a “New Drug Application” (NDA).

41.2(32) Possession of survey instrument. A licensee authorized to use radioactive material for uptake, dilution, and excretion studies shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range 0.1 millirem (1.0 μ Sv) per hour to 50 millirems (500 μ Sv) per hour. The instrument shall be operable and calibrated in accordance with 41.2(18).

41.2(33) *Use of radiopharmaceuticals, generators, and reagent kits for imaging and localization studies.*

a. A licensee may use any radioactive material in a diagnostic radiopharmaceutical or any generator or reagent kit for preparation and diagnostic use of a radiopharmaceutical containing radioactive material for which the Food and Drug Administration has a "Notice of Claimed Investigational Exemption for a New Drug" (IND) or approved a "New Drug Application" (NDA).

b. A licensee shall elute generators in compliance with subrule 41.2(34).

c. Provided that the conditions of subrule 41.2(35) are met, a licensee shall use radioactive aerosols or gases only if specific application is made to and approved by the agency.

41.2(34) *Permissible molybdenum-99 concentration.*

a. A licensee shall not administer a radiopharmaceutical containing more than 0.15 microcurie of molybdenum-99 per millicurie of technetium-99m (0.15 kilobecquerel of molybdenum-99 per megabecquerel of technetium-99m).

b. A licensee preparing technetium-99m radiopharmaceuticals from molybdenum-99/technetium-99m generators shall measure the molybdenum-99 concentration in each eluate or extract.

c. A licensee who must measure molybdenum concentration shall retain a record of each measurement for three years. The record shall include, for each elution or extraction of technetium-99m, the measured activity of the technetium expressed in millicuries (megabecquerels), the measured activity of molybdenum expressed in microcuries (kilobecquerels), the ratio of the measures expressed as microcuries of molybdenum per millicurie of technetium (kilobecquerels of molybdenum per megabecquerel of technetium), the date of the test, and the initials of the individual who performed the test.

d. A licensee shall report immediately to the agency each occurrence of molybdenum-99 concentration exceeding the limits specified in 41.2(34) "a."

41.2(35) *Control of aerosols and gases.*

a. A licensee who administers radioactive aerosols or gases shall do so with a system that will keep airborne concentrations within the limits prescribed by 641—40.15(136C) and 641—40.26(136C) of these rules.

b. The system shall either be directly vented to the atmosphere through an air exhaust or provide for collection and decay or disposal of the aerosol or gas in a shielded container.

c. A licensee shall only administer radioactive gases in rooms that are at negative pressure compared to surrounding rooms.

d. Before receiving, using, or storing a radioactive gas, the licensee shall calculate the amount of time needed after a release to reduce the concentration in the area of use to the occupational limit listed in Appendix B of 641—Chapter 40. The calculation shall be based on the highest activity of gas handled in a single container and the measured available air exhaust rate.

e. A licensee shall post the time calculated in 41.2(35) "a" at the area of use and require that, in case of a gas spill, individuals evacuate the room until the posted time has elapsed.

f. A licensee shall check the operation of collection systems monthly and measure the ventilation rates in areas of use at intervals not to exceed six months. Records of these checks and measurements shall be maintained for three years.

g. A copy of the calculations required in 41.2(35) "d" shall be recorded and retained for the duration of the license.

41.2(36) Possession of survey instruments. A licensee authorized to use radioactive material for imaging and localization studies shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range of 0.1 millirem ($1\ \mu\text{Sv}$) per hour to 50 millirems ($500\ \mu\text{Sv}$) per hour, and a portable radiation measurement survey instrument capable of measuring dose rates over the range of 1 millirem ($10\ \mu\text{Sv}$) per hour to 1000 millirems (10 mSv) per hour. The instruments shall be operable and calibrated in accordance with 41.2(18).

41.2(37) Use of radiopharmaceuticals for therapy. A licensee may use any radioactive material in a radiopharmaceutical and for a therapeutic use for which the Food and Drug Administration has a "Notice of Claimed Investigational Exemption for a New Drug" (IND) or approved a "New Drug Application" (NDA).

41.2(38) Safety instruction.

a. A licensee shall provide oral and written radiation safety instruction for all personnel caring for patients or human research subjects undergoing radiopharmaceutical therapy. Refresher training shall be provided at intervals not to exceed one year.

b. To satisfy 41.2(38) "a," the instruction shall describe the licensee's procedures for:

(1) Patient or human research subject control;

(2) Visitor control;

(3) Contamination control;

(4) Waste control;

(5) Notification of the radiation safety officer or authorized user in case of the patient's or human research subject's death or medical emergency; and

(6) Training requirements specified in 641—40.110(136C) and 40.116(136C) and adopted by reference and included herein.

c. A licensee shall keep a record of individuals receiving instruction required by 41.2(38) "a," a description of the instruction, the date of instruction, and the name of the individual who gave the instruction. Such record shall be maintained for inspection by the agency for three years.

41.2(39) Safety precautions.

a. For each patient or human research subject receiving radiopharmaceutical therapy and hospitalized for compliance with 41.2(27), a licensee shall:

(1) Provide a private room with a private sanitary facility;

(2) Post the patient's or human research subject's door with a "Caution: Radioactive Material" sign and note on the door or on the patient's or human research subject's chart where and how long visitors may stay in the patient's or human research subject's room;

(3) Authorize visits by individuals under 18 years of age only on a case-by-case basis with the approval of the authorized user after consultation with the radiation safety officer;

(4) Promptly after administration of the dosage, measure the dose rates in contiguous restricted and unrestricted areas with a radiation measurement survey instrument to demonstrate compliance with the requirements of 641—subrule 40.26(1) which is adopted by reference and included herein and retain for three years a record of each survey that includes the time and date of the survey, a plan of the area or list of points surveyed, the measured dose rate at several points expressed in millirems (μSv) per hour, the instrument used to make the survey, and the initials of the individual who made the survey;

(5) Either monitor material and items removed from the patient's or human research subject's room to determine that any contamination cannot be distinguished from the natural background radiation level with a radiation detection survey instrument set on its most sensitive scale and with no interposed shielding, or handle these materials and items as radioactive waste;

(6) Provide the patient or human research subject with radiation safety guidance that will help to keep radiation dose to household members and the public as low as reasonably achievable before authorizing release of the patient or human research subject;

(7) Survey the patient's or human research subject's room and private sanitary facility for removable contamination with a radiation detection survey instrument before assigning another patient or human research subject to the room. The room must not be reassigned until removable contamination is less than 200 disintegrations per minute (3.33 Bq) per 100 square centimeters; and

(8) Measure the thyroid burden of each individual who helped prepare or administer a dosage of iodine-131 during the period which starts the first day after administration and ends the fourth day after administering the dosage, and retain for the period required by 641—paragraph 40.82(2)“c” which is adopted and included herein a record of each thyroid burden measurement, date of measurement, the name of the individual whose thyroid burden was measured, and the initials of the individual who made the measurements.

b. A licensee shall notify the radiation safety officer or the authorized user immediately if the patient or human research subject dies or has a medical emergency.

41.2(40) Possession of survey instruments. A licensee authorized to use radioactive material for radiopharmaceutical therapy shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range of 0.1 millirem (1 μ Sv) per hour to 50 millirems (500 μ Sv) per hour, and a portable radiation measurement survey instrument capable of measuring dose rates over the range of 1 millirem (10 μ Sv) per hour to 1000 millirems (10 mSv) per hour. The instruments shall be operable and calibrated in accordance with 41.2(18).

41.2(41) Use of sealed sources for diagnosis. A licensee shall use the following sealed sources in accordance with the manufacturer's radiation safety and handling instructions:

- a. Iodine-125 as a sealed source in a device for bone mineral analysis;
- b. Americium-241 as a sealed source in a device for bone mineral analysis;
- c. Gadolinium-153 as a sealed source in a device for bone mineral analysis; and
- d. Iodine-125 as a sealed source in a portable device for imaging.

41.2(42) Availability of survey instrument. A licensee authorized to use radioactive material as a sealed source for diagnostic purposes shall have available for use a portable radiation detection survey instrument capable of detecting dose rates over the range of 0.1 millirem (1 μ Sv) per hour to 50 millirems (500 μ Sv) per hour or a portable radiation measurement survey instrument capable of measuring dose rates over the range of 1 millirem (10 μ Sv) per hour to 1000 millirems (10 mSv) per hour. The instrument shall be operable and calibrated in accordance with 41.2(18).

41.2(43) Use of sources for brachytherapy. A licensee shall use the following sources in accordance with the manufacturer's radiation safety and handling instructions:

- a. Cesium-137 as a sealed source in needles and applicator cells for topical, interstitial, and intracavitary treatment of cancer;
- b. Cobalt-60 as a sealed source in needles and applicator cells for topical, interstitial, and intracavitary treatment of cancer;
- c. Gold-198 as a sealed source in seeds for interstitial treatment of cancer;
- d. Iodine-125 as a sealed source in seeds for interstitial treatment of cancer;
- e. Iridium-192 as seeds encased in nylon ribbon for interstitial treatment of cancer;
- f. Radium-226 as a sealed source in needles or applicator cells for topical, interstitial, and intracavitary treatment of cancer;
- g. Radon-222 as seeds for interstitial treatment of cancer;
- h. Strontium-90 as a sealed source in an applicator for treatment of superficial eye conditions; and
- i. Palladium-103 as a sealed source in seeds for the interstitial treatment of cancer.

41.2(44) *Safety instruction.*

a. The licensee shall provide oral and written radiation safety instruction to all personnel caring for a patient or human research subject receiving implant therapy. Refresher training shall be provided at intervals not to exceed one year.

b. To satisfy 41.2(44)“a,” the instruction shall describe:

- (1) Size and appearance of the brachytherapy sources;
- (2) Safe handling and shielding instructions in case of a dislodged source;
- (3) Procedures for patient or human research subject control;
- (4) Procedures for visitor control;
- (5) Procedures for notification of the radiation safety officer or authorized user if the patient or human research subject dies or has a medical emergency; and
- (6) Training requirements specified in 641—40.110(136C) and 40.116(136C) as adopted by reference and included herein.

c. A licensee shall maintain a record of individuals receiving instruction required by 41.2(44)“a,” a description of the instruction, the date of instruction, and the name of the individual who gave the instruction for three years.

41.2(45) *Safety precautions.*

a. For each patient or human research subject receiving implant therapy a licensee shall:

(1) Not place the patient or human research subject in the same room with a patient who is not receiving radiation therapy unless the licensee can demonstrate compliance with the requirement of 641—40.26(136C) as adopted by reference and included herein at a distance of 1 meter from the implant;

(2) Post the patient’s or human research subject’s door with a “Caution: Radioactive Materials” sign and note on the door or the patient’s or human research subject’s chart where and how long visitors may stay in the patient’s or human research subject’s room;

(3) Authorize visits by individuals under 18 years of age only on a case-by-case basis with the approval of the authorized user after consultation with the radiation safety officer;

(4) Promptly after implanting the sources, survey the dose rates in contiguous restricted and unrestricted areas with a radiation measurement survey instrument to demonstrate compliance with 641—40.26(136C) as adopted by reference and included herein; and retain for three years a record of each survey that includes the time and date of the survey, a sketch of the area or list of points surveyed, the measured dose rate at several points expressed in millirems (mSv) per hour, the instrument used to make the survey, and the initials of the individual who made the survey; and

(5) Provide the patient or human research subject with radiation safety guidance that will help keep the radiation dose to household members and the public as low as reasonably achievable before releasing the patient or human research subject if the patient or human research subject was administered a permanent implant.

b. A licensee shall notify the radiation safety officer or authorized user immediately if the patient or human research subject dies or has a medical emergency.

41.2(46) *Brachytherapy sources inventory.*

a. Each time brachytherapy sources are returned to an area of storage from an area of use, the licensee shall immediately count or otherwise verify the number returned to ensure that all sources taken from the storage area have been returned.

b. A licensee shall make a record of brachytherapy source utilization which includes:

- (1) The names of the individuals permitted to handle the sources;
- (2) The number and activity of sources removed from storage, the room number of use and patient's or human research subject's name, the time and date they were removed from storage, the number and activity of sources in storage after the removal, and the initials of the individual who removed the sources from storage; and
- (3) The number and activity of sources returned to storage, the room number of use and patient's or human research subject's name, the time and date they were returned to storage, the number and activity of sources in storage after the return, and the initials of the individual who returned the sources to storage.

c. Immediately after implanting sources in a patient or human research subject and immediately after removal of sources from a patient or human research subject, the licensee shall make a radiation survey of the patient or human research subject and the area of use to confirm that no sources have been misplaced. The licensee shall make a record of each survey.

d. A licensee shall maintain the records required in 41.2(46) "b" and "c" for three years.

41.2(47) *Release of patients or human research subjects treated with temporary implants.*

a. Immediately after removing the last temporary implant source from a patient or human research subject, the licensee shall perform a radiation survey of the patient or human research subject with a radiation detection survey instrument to confirm that all sources have been removed. The licensee shall not release from confinement for medical care a patient or human research subject treated by temporary implant until all sources have been removed.

b. A licensee shall maintain a record of patient or human research subject surveys which demonstrate compliance with 41.2(47) "a" for three years. Each record shall include the date of the survey, the name of the patient or human research subject, the dose rate from the patient or human research subject expressed as millirems (microsieverts) per hour and measured within 1 meter from the patient or human research subject, and the initials of the individual who made the survey.

41.2(48) *Possession of survey instruments.* A licensee authorized to use radioactive material for implant therapy shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range of 0.1 millirem ($1 \mu\text{Sv}$) per hour to 50 millirems ($500 \mu\text{Sv}$) per hour, and a portable radiation measurement survey instrument capable of measuring dose rates over the range of 1 millirem ($10 \mu\text{Sv}$) per hour to 1000 millirems (10mSv) per hour. The instruments shall be operable and calibrated in accordance with 41.2(18).

41.2(49) *Use of a sealed source in a teletherapy unit.* A licensee shall use cobalt-60 or cesium-137 as a sealed source in a teletherapy unit for medical use in accordance with the manufacturer's radiation safety and operating instructions.

41.2(50) *Maintenance and repair restrictions.* Only a person specifically licensed by the agency, the U.S. Nuclear Regulatory Commission, or an agreement state to perform teletherapy unit maintenance and repair shall install, relocate, or remove a teletherapy sealed source or a teletherapy unit that contains a sealed source or maintain, adjust, or repair the source drawer, the shutter or other mechanism of a teletherapy unit that could expose the source, reduce the shielding around the source, or result in increased radiation levels.

41.2(51) Amendments. In addition to the requirements specified in 41.2(4), a licensee shall apply for and receive a license amendment before:

- a. Making any change in the treatment room shielding;
- b. Making any change in the location of the teletherapy unit within the treatment room;
- c. Using the teletherapy unit in a manner that could result in increased radiation levels in areas outside the teletherapy treatment room;
- d. Relocating the teletherapy unit; or
- e. Allowing an individual not listed on the licensee's license to perform the duties of the teletherapy physicist.

41.2(52) Safety instruction.

a. A licensee shall conspicuously post written instructions at the teletherapy unit console. These instructions shall inform the operator of:

(1) The procedure to be followed to ensure that only the patient or human research subject is in the treatment room before turning the primary beam of radiation "on" to begin a treatment or after a door interlock interruption;

(2) The procedure to be followed if the operator is unable to turn the primary beam of radiation "off" with controls outside the treatment room or any other abnormal operation occurs; and

(3) The names and telephone numbers of the authorized users and radiation safety officer to be immediately contacted if the teletherapy unit or console operates abnormally.

b. A licensee shall provide instruction in the topics identified in 41.2(52) "a" to all individuals who operate a teletherapy unit and shall provide appropriate refresher training to individuals at intervals not to exceed one year.

c. A licensee shall maintain a record of individuals receiving instruction required by 41.2(52) "b," a description of the instruction, the date of instruction, and the name of the individual who gave the instruction for three years.

41.2(53) Doors, interlocks, and warning systems.

a. A licensee shall control access to the teletherapy room by a door at each entrance.

b. A licensee shall equip each entrance to the teletherapy room with an electrical interlock system that shall:

(1) Prevent the operator from turning the primary beam of radiation "on" unless each treatment room entrance door is closed;

(2) Turn the beam of radiation "off" immediately when an entrance door is opened; and

(3) Prevent the primary beam of radiation from being turned "on" following an interlock interruption until all treatment room entrance doors are closed and the beam "on-off" control is reset at the console.

c. A licensee shall equip each entrance to the teletherapy room with a conspicuously visible beam condition indicator light.

41.2(54) Possession of survey instrument. A licensee authorized to use radioactive material in a teletherapy unit shall possess either a portable radiation detection survey instrument capable of detecting dose rates over the range of 0.1 millirem (1 μ Sv) per hour to 50 millirems (500 μ Sv) per hour or a portable radiation measurement survey instrument capable of measuring dose rates over the range of 1 millirem (10 μ Sv) per hour to 1000 millirems (10 mSv) per hour. The instruments shall be operable and calibrated in accordance with 41.2(18).

41.2(55) Radiation monitoring device.

a. A licensee shall have in each teletherapy room a permanent radiation monitor capable of continuously monitoring beam status.

b. Each radiation monitor shall be capable of providing visible notice of a teletherapy unit malfunction that results in an exposed or partially exposed source. The visible indicator of high radiation levels shall be observable by an individual entering the teletherapy room.

c. Each radiation monitor shall be equipped with a backup power supply separate from the power supply to the teletherapy unit. This backup power supply may be a battery system.

d. A radiation monitor shall be checked with a dedicated check source for proper operation each day before the teletherapy unit is used for treatment of patients or human research subjects.

e. A licensee shall maintain a record of the check required by 41.2(55)“d” for three years. The record shall include the date of the check, notation that the monitor indicates when the source is exposed, and the initials of the individual who performed the check.

f. If a radiation monitor is inoperable, the licensee shall require any individual entering the teletherapy room to use a survey instrument or audible alarm personal dosimeter to monitor for any malfunction of the source exposure mechanism. The instrument or dosimeter shall be checked with a dedicated check source for proper operation at the beginning of each day of use. The licensee shall keep a record as described in 41.2(55)“e.”

g. A licensee shall promptly repair or replace the radiation monitor if it is inoperable.

41.2(56) Viewing system. A licensee shall construct or equip each teletherapy room to permit continuous observation of the patient or human research subject from the teletherapy unit console during irradiation.

41.2(57) Dosimetry equipment.

a. A licensee shall have a calibrated dosimetry system available for use. To satisfy this requirement, one of the following two conditions shall be met:

(1) The system shall have been calibrated by the National Institute of Standards and Technology or by a calibration laboratory accredited by the American Association of Physicists in Medicine. The calibration shall have been performed within the previous two years and after any servicing that may have affected system calibration; or

(2) The system shall have been calibrated within the previous four years; 18 to 30 months after that calibration, the system shall have been intercompared at an inter-comparison meeting with another dosimetry system that was calibrated within the past 24 months by the National Institute of Standards and Technology or by a calibration laboratory accredited by the American Association of Physicists in Medicine. The intercomparison meeting shall be sanctioned by a calibration laboratory or radiologic physics center accredited by the American Association of Physicists in Medicine. The results of the intercomparison meeting must have indicated that the calibration factor of the licensee’s system had not changed by more than 2 percent. The licensee shall not use the intercomparison result to change the calibration factor. When intercomparing dosimetry systems to be used for calibrating cobalt-60 teletherapy units, the licensee shall use a teletherapy unit with a cobalt-60 source. When intercomparing dosimetry systems to be used for calibrating cesium-137 teletherapy units, the licensee shall use a teletherapy unit with a cesium-137 source.

b. The licensee shall have available for use a dosimetry system for spot-check measurements. To meet this requirement, the system may be compared with a system that has been calibrated in accordance with 41.2(57)“a.” This comparison shall have been performed within the previous year and after each servicing that may have affected system calibration. The spot-check system shall be the same system used to meet the requirement in 41.2(57)“a.”

c. The licensee shall maintain a record of each calibration, intercomparison, and comparison for the duration of the license. For each calibration, intercomparison, or comparison, the record shall include the date, the model numbers and serial numbers of the instruments that were calibrated, intercompared, or compared as required by 41.2(57) "a" and "b," the correction factors that were determined, the names of the individuals who performed the calibration, intercomparison, or comparison, and evidence that the intercomparison meeting was sanctioned by a calibration laboratory or radiologic physics center accredited by the American Association of Physicists in Medicine.

41.2(58) Full calibration measurements.

a. A licensee authorized to use a teletherapy unit for medical use shall perform full calibration measurements on each teletherapy unit:

- (1) Before the first medical use of the unit;
- (2) Before medical use under the following conditions:

1. Whenever spot-check measurements indicate that the output differs by more than 5 percent from the output obtained at the last full calibration corrected mathematically for radioactive decay;

2. Following replacement of the source or following reinstallation of the teletherapy unit in a new location; and

3. Following any repair of the teletherapy unit that includes removal of the source or major repair of the components associated with the source exposure assembly; and

- (3) At intervals not exceeding one year.

b. To satisfy the requirement of 41.2(58) "a," full calibration measurements shall include determination of:

(1) The output within 3 percent for the range of field sizes and for the distance or range of distances used for medical use;

(2) The coincidence of the radiation field and the field indicated by the light beam localizing device;

(3) The uniformity of the radiation field and its dependence on the orientation of the useful beam;

(4) Timer accuracy, constancy, and linearity;

(5) "On-off" error; and

(6) The accuracy of all distance measuring and localization devices in medical use.

c. A licensee shall use the dosimetry system described in 41.2(57) to measure the output for one set of exposure conditions. The remaining radiation measurements required in 41.2(58) "b"(1) may then be made using a dosimetry system that indicates relative dose rates.

d. A licensee shall make full calibration measurements required by 41.2(58) "a" in accordance with either the procedures recommended by the Scientific Committee on Radiation Dosimetry of the American Association of Physicists in Medicine that are described in *Physics in Medicine and Biology*, Vol. 16, No. 3, 1971, pp. 379-396, or by Task Group 21 of the Radiation Therapy Committee of the American Association of Physicists in Medicine that are described in *Medical Physics*, Vol. 10, No. 6, 1983, pp. 741-771, and Vol. 11, No. 2, 1984, p. 213.

e. A licensee shall correct mathematically the outputs determined in 41.2(58) "b"(1) for physical decay for intervals not exceeding one month for cobalt-60 and intervals not exceeding six months for cesium-137.

f. Full calibration measurements required by 41.2(58) "a" and physical decay corrections required by 41.2(58) "e" shall be performed by a teletherapy physicist named on the licensee's license or authorized by a license issued by the U.S. Nuclear Regulatory Commission or an agreement state to perform such services.

g. A licensee shall maintain a record of each calibration for the duration of the license. The record shall include the date of the calibration, the manufacturer's name, model number, and serial number for both the teletherapy unit and the source, the model numbers and serial numbers of the instruments used to calibrate the teletherapy unit, tables that describe the output of the unit over the range of field sizes and for the range of distances used in radiation therapy, a determination of the coincidence of the radiation field and the field indicated by the light beam localizing device, the measured timer accuracy for a typical treatment time, the calculated "on-off" error, the estimated accuracy of each distance measuring or localization device, and the signature of the teletherapy physicist.

41.2(59) Periodic spot checks.

a. A licensee authorized to use teletherapy units for medical use shall perform output spot checks on each teletherapy unit at intervals not to exceed one month.

b. To satisfy the requirement of 41.2(59) "a," spot checks shall include determination of:

- (1) Timer constancy and timer linearity over the range of use;
- (2) "On-off" error;
- (3) The coincidence of the radiation field and the field indicated by the light beam localizing device;
- (4) The accuracy of all distance measuring and localization devices used for medical use;
- (5) The output for one typical set of operating conditions; and
- (6) The difference between the measurement made in 41.2(59) "b"(5) and the anticipated output, expressed as a percentage of the anticipated output (i.e., the value obtained at last full calibration corrected mathematically for physical decay).

c. A licensee shall use the dosimetry system described in 41.2(57) to make the spot check required in 41.2(59) "b"(5).

d. A licensee shall perform spot checks required by 41.2(59) "a" in accordance with procedures established by the teletherapy physicist. The teletherapy physicist does not need to actually perform the output spot-check measurements.

e. A licensee shall have the teletherapy physicist review the results of each output spot check within 15 days. The teletherapy physicist shall promptly notify the licensee in writing of the results of each output spot check. The licensee shall keep a copy of each written notification for three years.

f. A licensee authorized to use a teletherapy unit for medical use shall perform safety spot checks of each teletherapy facility at intervals not to exceed one month.

g. To satisfy the requirement of 41.2(59) "f," safety spot checks shall ensure proper operation of:

- (1) Electrical interlocks at each teletherapy room entrance;
- (2) Electrical or mechanical stops installed for the purpose of limiting use of the primary beam of radiation restriction of source housing angulation or elevation, carriage or stand travel, and operation of the beam "on-off" mechanism;
- (3) Beam condition indicator lights on the teletherapy unit, on the control console, and in the facility;
- (4) Viewing systems;
- (5) Treatment room doors from inside and outside the treatment room; and
- (6) Electrically assisted treatment room doors with the teletherapy unit electrical power turned "off."

h. A licensee shall lock the control console in the "off" position if any door interlock malfunctions. No licensee shall use the unit until the interlock system is repaired unless specifically authorized by the agency.

i. A licensee shall promptly repair any system identified in 41.2(59) "g" that is not operating properly. The teletherapy unit shall not be used until all repairs are completed.

j. A licensee shall maintain a record of each spot check required by 41.2(59)“a” and “f” for three years. The record shall include the date of the spot check, the manufacturer’s name, model number, and serial number for both the teletherapy unit and source, the manufacturer’s name, model number and serial number of the instrument used to measure the output of the teletherapy unit, the timer constancy and linearity, the calculated “on-off” error, a determination of the coincidence of the radiation field and the field indicated by the light beam localizing device, the timer constancy and linearity for a typical treatment time, the calculated “on-off” error, the estimated accuracy of each distance measuring or localization device, the difference between the anticipated output and the measured output, notations indicating the operability of each entrance door electrical interlock, each electrical or mechanical stop, each beam condition indicator light, the viewing system and doors, and the signature of the individual who performed the periodic spot check.

41.2(60) Radiation surveys for teletherapy facilities.

a. Before medical use, after each installation of a teletherapy source, and after making any change for which an amendment is required by 41.2(51), the licensee shall perform radiation surveys with an operable radiation measurement survey instrument calibrated in accordance with 41.2(18) to verify that:

(1) The maximum and average radiation levels at 1 meter from the teletherapy source with the source in the “off” position and the collimators set for a normal treatment field do not exceed 10 millirems (100 μ Sv) per hour and 2 millirems (20 μ Sv) per hour, respectively; and

(2) With the teletherapy source in the “on” position with the largest clinically available treatment field, and with a scattering phantom in the primary beam of radiation, that:

1. Radiation levels in restricted areas are not likely to cause personnel exposures in excess of the limits specified in 641—40.15(136C); and

2. Radiation levels in unrestricted areas do not exceed the limits specified in 641—40.26(136C).

b. If the results of the surveys required in 41.2(60)“a” indicate any radiation levels in excess of the respective limit specified in that paragraph, the licensee shall lock the control in the “off” position and not use the unit:

(1) Except as may be necessary to repair, replace, or test the teletherapy unit, the teletherapy unit shielding, or the treatment room shielding; or

(2) Until the licensee has received a specific exemption from the agency.

c. A licensee shall maintain a record of the radiation measurements made following installation of a source for the duration of the license. The record shall include the date of the measurements, the reason the survey is required, the manufacturer’s name, model number and serial number of the teletherapy unit, the source, and the instrument used to measure radiation levels, each dose rate measured around the teletherapy source while in the “off” position and the average of all measurements, a plan of the areas surrounding the treatment room that were surveyed, the measured dose rate at several points in each area expressed in millirems (μ Sv) per hour, the calculated maximum level of radiation over a period of one week for each restricted and unrestricted area, and the signature of the radiation safety officer.

41.2(61) Safety spot checks for teletherapy facilities.

a. A licensee shall promptly check all systems listed in 41.2(59)“g” for proper function after each installation of a teletherapy source and after making any change for which an amendment is required by 41.2(51).

b. If the results of the safety spot checks required in 41.2(61)“a” indicate the malfunction of any system specified in 41.2(59), the licensee shall lock the control console in the “off” position and not use the unit except as may be necessary to repair, replace, or check the malfunctioning system.

c. A licensee shall maintain a record of the safety spot checks following installation of a source for three years. The record shall include notations indicating the operability of each entrance door interlock, each electrical or mechanical stop, each beam condition indicator light, the viewing system, doors, and the signature of the radiation safety officer.

41.2(62) *Modification of teletherapy unit or room before beginning a treatment program.* If the survey required by 41.2(60) indicates that an individual in an unrestricted area may be exposed to levels of radiation greater than those permitted by 641—40.26(136C) before beginning the treatment program the licensee shall:

a. Either equip the unit with stops or add additional radiation shielding to ensure compliance with 641—40.26(136C);

b. Perform the survey required by 41.2(60) again; and

c. Include in the report required by 41.2(63) the results of the initial survey, a description of the modification made to comply with 41.2(62) “a,” and the results of the second survey; or

d. Request and receive a license amendment under 641—40.26(136C) that authorizes radiation levels in unrestricted areas greater than those permitted by 641—40.26(136C).

41.2(63) *Reports of teletherapy surveys, checks, tests, and measurements.* A licensee shall furnish a copy of the records required in 41.2(60), 41.2(61), and 41.2(62) and the output from the teletherapy source expressed as rems (sieverts) per hour at 1 meter from the source as determined during the full calibration required in 41.2(58) to the agency within 30 days following completion of the action that initiated the record requirement.

41.2(64) *Five-year inspection.*

a. A licensee shall have each teletherapy unit fully inspected and serviced during teletherapy source replacement or at intervals not to exceed five years, whichever comes first, to ensure proper functioning of the source exposure mechanism.

b. This inspection and servicing shall be performed only by persons specifically licensed to do so by the agency, an agreement state, or the U.S. Nuclear Regulatory Commission.

c. A licensee shall maintain a record of the inspection and servicing for the duration of the license. The record shall contain the inspector’s name, the inspector’s license number, the date of inspection, the manufacturer’s name and model number and serial number for both the teletherapy unit and source, a list of components inspected, a list of components serviced and the type of service, a list of components replaced, and the signature of the inspector.

41.2(65) *Radiation safety officer.* Except as provided in 41.2(66), an individual fulfilling the responsibilities of the radiation safety officer as provided in 41.2(8) shall:

a. Be certified by the:

(1) American Board of Health Physics in comprehensive health physics;

(2) American Board of Radiology in radiological physics, therapeutic radiological physics, or medical nuclear physics;

(3) American Board of Nuclear Medicine;

(4) American Board of Science in Nuclear Medicine;

(5) Board of Pharmaceutical Specialties in Nuclear Pharmacy;

(6) American Board of Medical Physics in radiation oncology physics;

(7) Royal College of Physicians and Surgeons of Canada in nuclear medicine;

(8) American Osteopathic Board of Radiology; or

(9) American Osteopathic Board of Nuclear Medicine.

b. Have had 200 hours of classroom and laboratory training as follows:

(1) Radiation physics and instrumentation;

(2) Radiation protection;

(3) Mathematics pertaining to the use and measurement of radioactivity;

(4) Radiation biology;

(5) Radiopharmaceutical chemistry; and

(6) One year of full-time experience in radiation safety at a medical institution under the supervision of the individual identified as the radiation safety officer on an agency, agreement state, licensing state, or U.S. Nuclear Regulatory Commission license that authorizes the medical use of radioactive material; or

c. Be an authorized user for those radioactive material uses that come within the radiation safety officer's responsibilities.

41.2(66) *Training for experienced radiation safety officer.* An individual identified as a radiation safety officer on an agency, agreement state, licensing state, or U.S. Nuclear Regulatory Commission license on September 1, 1992, who oversees only the use of radioactive material for which the licensee was authorized on that date need not comply with the training requirements of 41.2(65).

41.2(67) *Training for uptake, dilution, or excretion studies.* Except as provided in 41.2(75) and 41.2(76), the licensee shall require the authorized user of a radiopharmaceutical listed in 41.2(31) to be a physician who:

a. Is certified in:

- (1) Nuclear medicine by the American Board of Nuclear Medicine;
- (2) Diagnostic radiology by the American Board of Radiology;
- (3) Diagnostic radiology or radiology within the previous five years by the American Osteopathic Board of Radiology; or

- (4) Nuclear medicine by the American Osteopathic Board of Nuclear Medicine; or
- (5) Nuclear medicine by the Royal College of Physicians and Surgeons of Canada; or

b. Has completed 40 hours of instruction in basic radionuclide handling techniques applicable to the use of prepared radiopharmaceuticals, and 20 hours of supervised clinical experience.

(1) To satisfy the basic instruction requirement, 40 hours of classroom and laboratory instruction shall include:

1. Radiation physics and instrumentation;
2. Radiation protection;
3. Mathematics pertaining to the use and measurement of radioactivity;
4. Radiation biology; and
5. Radiopharmaceutical chemistry.

(2) To satisfy the requirement for 20 hours of supervised clinical experience, training must be under the supervision of an authorized user at a medical institution and shall include:

1. Examining patients or human research subjects and reviewing their case histories to determine their suitability for radionuclide diagnosis, limitations, or contraindications;
2. Selecting the suitable radiopharmaceuticals and calculating and measuring the dosages;
3. Administering dosages to patients or human research subjects and using syringe radiation shields;
4. Collaborating with the authorized user in the interpretation of radionuclide test results; and
5. Patient or human research subject follow-up; or

c. Has successfully completed a six-month training program in nuclear medicine as part of a training program that has been approved by the Accreditation Council for Graduate Medical Education and that included classroom and laboratory training, work experience, and supervised clinical experience in all the topics identified in 41.2(67) "b";

d. Be identified on a current Agreement State or NRC license as an authorized user for use listed in 41.2(31).

41.2(68) *Training for imaging and localization studies.* Except as provided in 41.2(75) and 41.2(76), the licensee shall require the authorized user of a radiopharmaceutical, generator, or reagent kit specified in 41.2(33) to be a physician who:

- a. Is certified in:
 - (1) Nuclear medicine by the American Board of Nuclear Medicine;
 - (2) Diagnostic radiology by the American Board of Radiology;
 - (3) Diagnostic radiology or radiology within the previous five years by the American Osteopathic Board of Radiology; or
 - (4) Nuclear medicine by the American Osteopathic Board of Nuclear Medicine; or
 - (5) Nuclear medicine by the Royal College of Physicians and Surgeons of Canada; or
- b. Has completed 200 hours of instruction in basic radionuclide handling techniques applicable to the use of prepared radiopharmaceuticals, generators, and reagent kits, 500 hours of supervised work experience, and 500 hours of supervised clinical experience.
 - (1) To satisfy the basic instruction requirement, 200 hours of classroom and laboratory training shall include:
 1. Radiation physics and instrumentation;
 2. Radiation protection;
 3. Mathematics pertaining to the use and measurement of radioactivity;
 4. Radiopharmaceutical chemistry; and
 5. Radiation biology.
 - (2) To satisfy the requirement for 500 hours of supervised work experience, training shall be under the supervision of an authorized user at a medical institution and shall include:
 1. Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;
 2. Calibrating dose calibrators and diagnostic instruments and performing checks for proper operation of survey meters;
 3. Calculating and safely preparing patient or human research subject dosages;
 4. Using administrative controls to prevent the misadministration of radioactive material;
 5. Using emergency procedures to contain spilled radioactive material safely and using proper decontamination procedures; and
 6. Eluting technetium-99m from generator systems, assaying and testing the eluate for molybdenum-99 and alumina contamination, and processing the eluate with reagent kits to prepare technetium-99m labeled radiopharmaceuticals.
 - (3) To satisfy the requirement for 500 hours of supervised clinical experience, training shall be under the supervision of an authorized user at a medical institution and shall include:
 1. Examining patients or human research subjects and reviewing their case histories to determine their suitability for radionuclide diagnosis, limitations, or contraindications;
 2. Selecting the suitable radiopharmaceuticals and calculating and measuring the dosages;
 3. Administering dosages to patients or human research subjects and using syringe radiation shields;
 4. Collaborating with the authorized user in the interpretation of radionuclide test results; and
 5. Patient or human research subject follow-up; or
- c. Has successfully completed a six-month training program in nuclear medicine that has been approved by the Accreditation Council for Graduate Medical Education and that included classroom and laboratory training, work experience, and supervised clinical experience in all the topics identified in 41.2(68)“b”;
- d. Be identified on a current Agreement State or NRC license as an authorized user for those uses listed in 41.2(33).

41.2(69) *Training for therapeutic use of radiopharmaceuticals.* Except as provided in 41.2(75), the licensee shall require the authorized user of a radiopharmaceutical listed in 41.2(37) for therapy to be a physician who:

a. Is certified by:

- (1) The American Board of Nuclear Medicine; or
- (2) The American Board of Radiology in radiology, therapeutic radiology, or radiation oncology;

or

- (3) Nuclear medicine by the Royal College of Physicians and Surgeons of Canada; or
- (4) The American Osteopathic Board of Radiology after 1984; or

b. Has completed 80 hours of instruction in basic radionuclide handling techniques applicable to the use of therapeutic radiopharmaceuticals, and has had supervised clinical experience.

(1) To satisfy the requirement for instruction, 80 hours of classroom and laboratory training shall include:

1. Radiation physics and instrumentation;
2. Radiation protection;
3. Mathematics pertaining to the use and measurement of radioactivity; and
4. Radiation biology;

(2) To satisfy the requirement for supervised clinical experience, training shall be under the supervision of an authorized user at a medical institution and shall include:

1. Use of iodine-131 for diagnosis of thyroid function and the treatment of hyperthyroidism or cardiac dysfunction in ten individuals;
2. Use of soluble phosphorus-32 for the treatment of ascites, polycythemia vera, leukemia, or bone metastases in three individuals;
3. Use of iodine-131 for treatment of thyroid carcinoma in three individuals;
4. Use of colloidal chromic phosphorus-32 or of colloidal gold-198 for intracavitary treatment of malignant effusions in three individuals; and
5. Use of strontium-89 for relief of pain in metastatic disease in three individuals; or

c. Be identified on a current Agreement State or NRC license as an authorized user for these uses in 41.2(37).

41.2(70) *Training for therapeutic use of brachytherapy sources.* Except as provided in 41.2(75), the licensee shall require the authorized user using a brachytherapy source specified in 41.2(43) for therapy to be a physician who:

a. Is certified in:

- (1) Radiology, therapeutic radiology, or radiation oncology by the American Board of Radiology;
- (2) Radiation oncology by the American Osteopathic Board of Radiology;
- (3) Radiology, with a specialization in radiotherapy, as a British "Fellow of the Faculty of Radiology" or "Fellow of the Royal College of Radiology"; or
- (4) Therapeutic radiology by the Canadian Royal College of Physicians and Surgeons; or

b. Is in the active practice of therapeutic radiology, has completed 200 hours of instruction in basic radionuclide handling techniques applicable to the therapeutic use of brachytherapy sources and 500 hours of supervised work experience and a minimum of three years of supervised clinical experience.

(1) To satisfy the requirement for instruction, 200 hours of classroom and laboratory training shall include:

1. Radiation physics and instrumentation;
2. Radiation protection;
3. Mathematics pertaining to the use and measurement of radioactivity; and
4. Radiation biology.

(2) To satisfy the requirement for 500 hours of supervised work experience, training shall be under the supervision of an authorized user at a medical institution and shall include:

1. Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;
2. Checking survey meters for proper operation;
3. Preparing, implanting, and removing sealed sources;
4. Using administrative controls to prevent the misadministration of radioactive material; and
5. Using emergency procedures to control radioactive material.

(3) To satisfy the requirement for a period of supervised clinical experience, training shall include one year in a formal training program approved by the Residency Review Committee for Radiology of the Accreditation Council for Graduate Medical Education or the Committee on Postdoctoral Training of the American Osteopathic Association, and an additional two years of clinical experience in therapeutic radiology under the supervision of an authorized user at a medical institution. The supervised clinical experience shall include:

1. Examining individuals and reviewing their case histories to determine their suitability for brachytherapy treatment, and any limitations or contraindications;
2. Selecting the proper brachytherapy sources, dose, and method of administration;
3. Calculating the dose; and
4. Postadministration follow-up and review of case histories in collaboration with the authorized user; or

c. Be identified on a current Agreement State or NRC license as an authorized user for the uses in 41.2(43).

41.2(71) *Training for ophthalmic use of strontium-90.* Except as provided in 41.2(75), the licensee shall require the authorized user using only strontium-90 for ophthalmic radiotherapy to be a physician who:

a. Is certified in radiology, therapeutic radiology, or radiation oncology by the American Board of Radiology; or

b. Is in the active practice of therapeutic radiology or ophthalmology, and has completed 24 hours of instruction in basic radionuclide handling techniques applicable to the use of strontium-90 for ophthalmic radiotherapy, and a period of supervised clinical training in ophthalmic radiotherapy.

(1) To satisfy the requirement for instruction, the classroom and laboratory training shall include:

1. Radiation physics and instrumentation;
2. Radiation protection;
3. Mathematics pertaining to the use and measurement of radioactivity; and
4. Radiation biology.

(2) To satisfy the requirement for a period of supervised clinical training in ophthalmic radiotherapy, training shall be under the supervision of an authorized user at a medical institution and shall include the use of strontium-90 for the ophthalmic treatment of five individuals that includes:

1. Examination of each individual to be treated;
2. Calculation of the dose to be administered;
3. Administration of the dose; and
4. Follow-up and review of each individual's case history; or

c. Be identified on a current Agreement State or NRC license as an authorized user for the use in 41.2(43) "h."

41.2(72) *Training for use of sealed sources for diagnosis.* Except as provided in 41.2(75), the licensee shall require the authorized user using a sealed source in a device specified in 41.2(41) to be a physician, dentist, or podiatrist who:

- a. Is certified in:
 - (1) Radiology, diagnostic radiology with special competence in nuclear radiology, therapeutic radiology, or radiation oncology by the American Board of Radiology;
 - (2) Nuclear medicine by the American Board of Nuclear Medicine; or
 - (3) Diagnostic radiology or radiology by the American Osteopathic Board of Radiology; or
 - (4) Nuclear medicine by the Royal College of Physicians and Surgeons of Canada; or
- b. Has completed eight hours of classroom and laboratory instruction in basic radionuclide handling techniques specifically applicable to the use of the device.
 - (1) To satisfy the requirements for instruction, the training shall include:
 1. Radiation physics, mathematics pertaining to the use and measurement of radioactivity, and instrumentation;
 2. Radiation biology; and
 3. Radiation protection and training in the use of the device for the purposes authorized by the license.

(2) Reserved; or
c. Be identified on a current Agreement State or NRC license as an authorized user for those uses in 41.2(41).

41.2(73) *Training for teletherapy.* Except as provided in 41.2(75), the licensee shall require the authorized user of a sealed source specified in 41.2(49) in a teletherapy unit to be a physician who:

- a. Is certified in:
 - (1) Radiology, therapeutic radiology, or radiation oncology by the American Board of Radiology;
 - (2) Radiation oncology by the American Osteopathic Board of Radiology;
 - (3) Radiology, with specialization in radiotherapy, as a British "Fellow of the Faculty of Radiology" or "Fellow of the Royal College of Radiology"; or
 - (4) Therapeutic radiology by the Canadian Royal College of Physicians and Surgeons; or
- b. Is in the active practice of therapeutic radiology, and has completed 200 hours of instruction in basic radionuclide techniques applicable to the use of a sealed source in a teletherapy unit, 500 hours of supervised work experience, and a minimum of three years of supervised clinical experience.
 - (1) To satisfy the requirement for instruction, the classroom and laboratory training shall include:
 1. Radiation physics and instrumentation;
 2. Radiation protection;
 3. Mathematics pertaining to the use and measurement of radioactivity; and
 4. Radiation biology.
 - (2) To satisfy the requirement for supervised work experience, training shall be under the supervision of an authorized user at an institution and shall include:
 1. Review of the full calibration measurements and periodic spot checks;
 2. Preparing treatment plans and calculating treatment times;
 3. Using administrative controls to prevent misadministrations;
 4. Implementing emergency procedures to be followed in the event of the abnormal operation of a teletherapy unit or console; and
 5. Checking and using survey meters.

(3) To satisfy the requirement for a period of supervised clinical experience, training shall include one year in a formal training program approved by the Residency Review Committee for Radiology of the Accreditation Council for Graduate Medical Education or the Committee on Postdoctoral Training of the American Osteopathic Association and an additional two years of clinical experience in therapeutic radiology under the supervision of an authorized user at a medical institution. The supervised clinical experience shall include:

1. Examining individuals and reviewing their case histories to determine their suitability for teletherapy treatment and any limitations or contraindications;
 2. Selecting the proper dose and how it is to be administered;
 3. Calculating the teletherapy doses and collaborating with the authorized user in the review of patients' or human research subjects' progress and consideration of the need to modify originally prescribed doses as warranted by patients' or human research subjects' reaction to radiation; and
 4. Postadministration follow-up and review of case histories;
- c. Be identified on a current Agreement State or NRC license as an authorized user for teletherapy.

41.2(74) *Training for teletherapy physicist.* The licensee shall require the teletherapy physicist to:

- a. Be certified by:
 - (1) The American Board of Radiology in:
 1. Therapeutic radiological physics;
 2. Roentgen-ray and gamma-ray physics;
 3. X-ray and radium physics; or
 4. Radiological physics; or
 5. The American Board of Medical Physics in radiation oncology physics; or
- (2) Reserved; or
- b. Hold a master's or doctor's degree in physics, biophysics, radiological physics, or health physics, and have completed one year of full-time training in therapeutic radiological physics and also one year of full-time work experience under the supervision of a teletherapy physicist at a medical institution. To meet this requirement, the individual shall have performed the tasks listed in 41.2(21), 41.2(58), 41.2(59), and 41.2(60) under the supervision of a teletherapy physicist during the year of work experience.

- c. Be identified on a current Agreement State or NRC license as a teletherapy physicist.

41.2(75) *Training for experienced authorized users.* Rescinded IAB 8/3/94, effective 9/7/94.

41.2(76) *Physician training in a three-month program.* A physician who, before July 1, 1984, began a three-month nuclear medicine training program approved by the Accreditation Council for Graduate Medical Education and has successfully completed the program, is exempted from the requirements of 41.2(67) or 41.2(68).

41.2(77) *Recentness of training.* The training and experience specified in 41.2(65) to 41.2(79) shall have been obtained within the seven years preceding the date of application or the individual shall have had related continuing education and continuing applicable experience since the required training and experience was completed.

41.2(78) *Training for an authorized nuclear pharmacist.* The licensee shall require the authorized nuclear pharmacist to be a pharmacist who:

- a. Has current board certification as a nuclear pharmacist by the board of pharmaceutical specialties, or

b. Has completed:

(1) 700 hours in a structured educational program consisting of both:

1. Didactic training in the following areas:

- Radiation physics and instrumentation;
- Radiation protection;
- Mathematics pertaining to the use and measurement of radioactivity;
- Chemistry of radioactive material for medical use; and
- Radiation biology; and

2. Supervised experience in a nuclear pharmacy involving the following:

- Shipping, receiving, and performing related radiation surveys;
- Using and performing checks for proper operation of dose calibrators, survey meters, and if appropriate, instruments used to measure alpha- or beta-emitting radionuclides;
- Calculating, assaying, and safely preparing dosages for patients or human research subjects;
- Using administrative controls to avoid mistakes in the administration of radioactive material;
- Using procedures to prevent or minimize contamination and using proper decontamination procedures; and

(2) Has obtained written certification, signed by a preceptor authorized nuclear pharmacist, that the above training has been satisfactorily completed and that the individual has achieved a level of competency sufficient to independently operate a nuclear pharmacy.

41.2(79) *Training for experienced nuclear pharmacists.* A licensee may apply for and must receive a license amendment identifying an experienced nuclear pharmacist as an authorized nuclear pharmacist before it allows this individual to work as an authorized nuclear pharmacist. A pharmacist who has completed a structured educational program as specified in 41.2(78) “*b*” before December 2, 1994, and who is working in a nuclear pharmacy would qualify as an experienced nuclear pharmacist. An experienced nuclear pharmacist need not comply with the requirements on preceptor statement in 41.2(78) “*b*”(2) and recency of training in 41.2(77) to qualify as an authorized nuclear pharmacist.

641—41.3(136C) Therapeutic use of radiation machines.

41.3(1) Scope and applicability.

a. This subrule establishes requirements, for which the registrant is responsible, for use of therapeutic radiation machines.

b. The use of therapeutic radiation machines shall be by, or under the supervision of, a licensed practitioner of the healing arts who meets the training/experience criteria established by 41.3(4) “*c*.”

c. Unless specifically required otherwise by 641—41.3(136C), all registrants are subject to the requirements of 641—Chapters 38 to 40.

41.3(2) Definitions. The following definitions are specific to 641—41.3(136C).

“*Accessible surface*” means surface of equipment or of an equipment part that can be easily or accidentally touched by persons without the use of a tool.

“*Added filtration*” means any filtration which is in addition to the inherent filtration.

“*Beam axis*” means the axis of rotation of the beam-limiting device.

“*Beam-limiting device*” means a field defining collimator, integral to the therapeutic radiation machine, which provides a means to restrict the dimensions of the useful beam.

“*Beam-scattering foil*” means a thin piece of material (usually metallic) placed in the beam to scatter a beam of electrons in order to provide a more uniform electron distribution in the useful beam.

“Bent beam linear accelerator” means a linear accelerator geometry in which the accelerated electron beam must change direction by passing through a bending magnet.

“Contact therapy system” means a therapeutic radiation machine with a short target-to-skin distance (TSD), usually less than 5 centimeters.

“Dose monitor unit (DMU)” means a unit response from the beam monitoring system from which the absorbed dose can be calculated.

“External beam radiation therapy” means therapeutic irradiation in which the source of radiation is at a distance from the body.

“Field flattening filter” means a filter used to homogenize the absorbed dose rate over the radiation field.

“Filter” means material placed in the useful beam to change beam quality in therapeutic radiation machines subject to subrule 41.3(6).

“Gantry” means that part of a radiation therapy system supporting and allowing movements of the radiation head around a center of rotation.

“Interruption of irradiation” means the stopping of irradiation with the possibility of continuing irradiation without resetting of operating conditions at the control panel.

“Isocenter” means the center of the sphere through which the useful beam axis passes while the gantry moves through its full range of motions.

“Kilo electron volt (keV)” means the energy equal to that acquired by a particle with one electron charge in passing through a potential difference of 1000 volts in a vacuum.

“Megavolt (MV) (mega electron volt (MeV))” means the energy equal to that acquired by a particle with one electron charge in passing through a potential difference of 1 million volts in a vacuum. (Note: Current convention is to use MV for photons and MeV for electrons.)

“Monitor unit (MU).” See “Dose monitor unit.”

“Moving beam radiation therapy” means radiation therapy with continuous displacement of one or more mechanical axes relative to the patient during irradiation. It includes arc therapy, skip therapy, conformal therapy and rotational therapy.

“Nominal treatment distance” means:

1. For electron irradiation, the distance from the scattering foil, or exit window, of the electron beam to the entrance surface of the irradiated object along the central axis of the useful beam.
2. For X-ray irradiation target to isocenter distance along the central axis of the useful beam. For nonisocentric equipment, this distance shall be that specified by the manufacturer.

“Periodic quality assurance check” means a procedure which is performed to ensure that a previous calibration continues to be valid.

“Practical range of electrons” corresponds to classical electron range where the only remaining contribution to dose is from bremsstrahlung X-rays. A further explanation may be found in “Clinical Electron Beam Dosimetry: Report of AAPM Radiation Therapy Committee Task Group 25” (Medical Physics 18(1): 73-109, Jan/Feb 1991) and ICRU Report 35, “Radiation Dosimetry: Electron Beams with Energies Between 1 and 50 MeV,” International Agency on Radiation Units and Measurements, September 15, 1984.

“Radiation detector” means a device which in the presence of radiation provides, by either direct or indirect means, a signal or other indication suitable for use in measuring one or more quantities of incident radiation.

“Radiation field.” See “Useful beam.”

“Radiation head” means the structure from which the useful beam emerges.

“Radiation therapy physicist” means an individual qualified in accordance with 41.3(4)“d.”

“Redundant beam monitoring system” means a combination of two dose monitoring systems in which each system is designed to terminate irradiation in accordance with a preselected number of dose monitor units.

“*Shadow tray*” means a device attached to the radiation head to support auxiliary beam blocking material.

“*Stationary beam radiation therapy*” means radiation therapy without displacement of one or more mechanical axes relative to the patient during irradiation.

“*Target*” means that part of an X-ray tube or accelerator onto which is directed a beam of accelerated particles to produce ionizing radiation or other particles.

“*Target-to-skin distance (TSD)*” means the distance measured along the beam axis from the center of the front surface of the X-ray target or electron scattering foil to the surface of the irradiated object or patient.

“*Tenth-value layer (TVL)*” means the thickness of a specified material which attenuates X-radiation or gamma radiation to an extent such that the air kerma rate, exposure rate or absorbed dose rate is reduced to one-tenth of the value measured without the material at the same point.

“*Therapeutic radiation machine*” means X-ray or electron-producing equipment designed and used for external beam radiation therapy.

“*Virtual source*” means a point from which radiation appears to originate.

41.3(3) Registration or license requirements. No person shall receive, possess, use, transfer, own, or acquire therapeutic radiation machines except as authorized in a registration issued pursuant to 641—39.1(136C) to 39.4(136C).

41.3(4) General administrative requirements for facilities using therapeutic radiation machines.

a. Administrative controls. The registrant shall be responsible for directing the operation of the therapeutic radiation machines which have been registered with the agency. The registrant or the registrant’s agent shall ensure that the requirements of 41.3(136C) are met in the operation of the therapeutic radiation machine(s).

b. A therapeutic radiation machine which does not meet the provisions of these regulations shall not be used for irradiation of patients unless authorized by the agency.

41.3(5) Training for external beam radiation therapy authorized users. The registrant for any therapeutic radiation machine subject to 41.3(17) or 41.3(18) shall require the authorized user to be a physician who:

a. Is certified in:

- (1) Radiology or therapeutic radiology by the American Board of Radiology; or
- (2) Radiation oncology by the American Osteopathic Board of Radiology; or
- (3) Radiology, with specialization in radiotherapy, as a British “Fellow of the Faculty of Radiology” or “Fellow of the Royal College of Radiology”; or

(4) Therapeutic radiology by the Canadian Royal College of Physicians and Surgeons; or

b. Is in the active practice of therapeutic radiology, and has completed 200 hours of instruction in basic radiation techniques applicable to the use of an external beam radiation therapy unit, 500 hours of supervised work experience, and a minimum of three years of supervised clinical experience.

c. To satisfy the requirement for instruction in 41.3(5) “*b*” above, the classroom and laboratory training shall include:

- (1) Radiation physics and instrumentation;
- (2) Radiation protection;
- (3) Mathematics pertaining to the use and measurement of ionization radiation; and
- (4) Radiation biology.

d. To satisfy the requirement for supervised work experience in 41.3(4)“*b*” above, training shall be under the supervision of an authorized user and shall include:

- (1) Reviewing the full calibration measurements and periodic quality assurance checks;
- (2) Evaluating prepared treatment plans and calculation of treatment times/patient treatment settings;
- (3) Using administrative controls to prevent misadministrations;
- (4) Implementing emergency procedures to be followed in the event of the abnormal operation of an external beam radiation therapy unit or console; and
- (5) Checking and using radiation survey meters.

e. To satisfy the requirement for a period of supervised clinical experience, training shall include one year in a formal training program approved by the Residency Review Committee for Radiology of the Accreditation Council for Graduate Medical Education or the Committee on Postdoctoral Training of the American Osteopathic Association and an additional two years of clinical experience in therapeutic radiology under the supervision of an authorized user. The supervised clinical experience shall include:

- (1) Examining individuals and reviewing their case histories to determine their suitability for external beam radiation therapy treatment, and any limitations/contraindications;
- (2) Selecting proper dose and how it is to be administered;
- (3) Calculating the external beam radiation therapy doses and collaborating with the authorized user in the review of patients’ progress; consideration of the need to modify originally prescribed doses or treatment plans as warranted by patients’ reaction to radiation; and
- (4) Postadministration follow-up and review of case histories.

f. Notwithstanding the requirements of 41.3(4)“*b*,” the registrant for any therapeutic radiation machine subject to 41.3(7) may also submit the training of the prospective authorized user physician for agency review.

41.3(6) Training for radiation therapy physicist. The registrant for any therapeutic radiation machine subject to 41.3(17) or (18) shall require the radiation therapy physicist to:

a. Be registered with the agency, under the provisions of 641—subrule 39.3(3) of these regulations, as a provider of radiation services in the area of calibration and compliance surveys of external beam radiation therapy units; and

b. Be certified by the American Board of Radiology in:

- (1) Therapeutic radiological physics; or
- (2) Roentgen-ray and gamma-ray physics; or
- (3) X-ray and radium physics; or
- (4) Radiological physics; or

c. Be certified by the American Board of Medical Physics in radiation oncology physics; or

d. Be certified by the Canadian College of Medical Physics; or

e. Hold a master’s or doctorate degree in physics, biophysics, radiological physics, or health physics, and have completed one year of full-time training in therapeutic radiological physics and also one year of full-time work experience under the supervision of a radiation therapy physicist at a medical institution. To meet this requirement, the individual shall have performed the tasks listed in 41.3(16)“*a*”(1), 41.3(17)“*c*,” 41.3(17)“*c*”(5), 41.3(18)“*e*,” and 41.3(18)“*f*” under the supervision of a radiation therapy physicist during the year of work experience.

f. Notwithstanding the provisions of 41.3(6)“*e*,” certification pursuant to 41.3(6)“*b*,” 41.3(6)“*c*” or 41.3(6)“*d*” shall be required on or before December 31, 1999, for all persons currently qualifying as a radiation therapy physicist pursuant to 41.3(6)“*e*.”

41.3(7) Qualifications of operators.

a. Individuals who will be operating a therapeutic radiation machine for medical use shall be adequately instructed in the safe operating procedures and be competent in the safe use of the equipment in accordance with 641—Chapter 42 as applicable.

b. Each operator's permit to practice under 641—Chapter 42 shall be posted in the immediate vicinity of the general work area and visible to the public.

41.3(8) Written safety procedures and rules shall be developed by a radiation therapy physicist and shall be available in the control area of a therapeutic radiation machine, including any restrictions required for the safe operation of the particular therapeutic radiation machine.

41.3(9) Individuals shall not be exposed to the useful beam except for medical therapy purposes and unless such exposure has been ordered in writing by a licensed practitioner of the healing arts. This provision specifically prohibits deliberate exposure of an individual for training, demonstration or other non-healing arts purposes.

41.3(10) Records of authorized users. Notwithstanding the provisions of 41.3(4)“g,” a registrant may permit any physician to act as an authorized user under the following conditions:

a. The authorized user has the prior written permission of the registrant's management if the use occurs on behalf of an institution, and

b. The registrant maintains copies of all records specified in 41.3(4)“h” for five years from the date of the last visit.

41.3(11) Information and maintenance record and associated information. The registrant shall maintain the following information for each therapeutic radiation machine for inspection by the agency:

a. Report of acceptance testing;

b. Records of all surveys, calibrations, and periodic quality assurance checks of the therapeutic radiation machine required by 41.3(136C), as well as the name(s) of person(s) who performed such activities;

c. Records of maintenance or modifications, or both, performed on the therapeutic radiation machine after July 9, 1997, as well as the name(s) of person(s) who performed such services;

d. Signature of person authorizing the return of therapeutic radiation machine to clinical use after service, repair, or upgrade.

41.3(12) Records retention. All records required by 641—41.3(136C) shall be retained until disposal is authorized by the agency unless another retention period is specifically authorized in 41.3(136C).

41.3(13) Form of records. Each record required by 41.3(136C) shall be legible throughout the specified retention period. The record shall be the original or a reproduced copy or microfilm, provided that the copy or microfilm is authenticated by authorized personnel and that the microfilm is capable of producing a clear copy throughout the required retention period, or the record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records, such as letters, drawings, and specifications, shall include all pertinent information, such as stamps, initials, and signatures. The registrant shall maintain adequate safeguards against tampering with and loss of records.

41.3(14) Written directives. Each registrant shall meet the following objectives:

- a.* That, prior to each administration, a written directive¹ is prepared for any therapeutic dose;
- b.* That prior to each initial administration of a treatment series, the patient's identity is verified as the individual named in the written directive;
- c.* That final plans of treatment and related calculations for the therapy are in accordance with the respective written objectives;
- d.* That each administration is in accordance with the written directive;
- e.* That any unintended deviation from the written directive is identified and evaluated, and appropriate action taken.
- f.* The registrant shall retain:
 - (1) Each written directive; and
 - (2) A record of each administered radiation dose, in an auditable form, for three years after the date of administration.

41.3(15) Misadministration.

a. When a misadministration involves any therapeutic procedure, the registrant shall notify the agency by telephone. The registrant shall also notify the referring physician of the affected patient and the patient or the responsible relative or guardian, unless the referring physician agrees to inform the patient or believes, based on medical judgment, that telling the patient or responsible relative or guardian would be medically harmful for the patient. These notifications must be made within 24 hours after the registrant discovers the misadministration. If the referring physician, patient, or patient's responsible relative or guardian cannot be reached within 24 hours, the registrant shall notify all of them as soon as practicable. The registrant is not required to notify the patient or patient's responsible relative or guardian without first consulting the referring physician; however, the registrant shall not delay medical care for the patient because of this.

b. Within 15 days after the initial therapy misadministration report to the agency, the registrant shall report, in writing, to the agency and referring physician, and furnish a copy of the report to the patient or the patient's responsible relative or guardian if either was notified by the registrant as required by 41.3(15) "a." The written report shall include the registrant's name; the referring physician's name; a brief description of the event causing the misadministration; the effect on the patient; the action to prevent recurrence; and whether the registrant informed the patient or patient's responsible relative or guardian, and if not, why. The report shall not include the patient's name or other information that could lead to the identification of the patient.

c. Each registrant shall retain records of misadministrations for ten years. The records shall include the names of all individuals involved in the event, including the physician, allied health personnel, the patient, patient's referring physician, the patient's social security number or identification number if assigned, a brief description of the event, the effect on the patient, and action taken, if any, to prevent recurrence.

d. Aside from the notification requirement, nothing in 41.3(15) "a," 41.3(15) "b" or 41.3(15) "c" shall affect any rights or duties of registrants and physicians in relation to each other, patients, or responsible relatives or guardians.

¹If, because of the patient's condition, a delay in the order to provide a written revision to an existing written directive would jeopardize the patient's health, an oral revision to an existing written directive will be acceptable, provided that the oral revision is documented immediately in the patient's record and a revised written directive is signed by the authorized user within 48 hours of the oral revision.

Also, a written directive revision to an existing written directive may be made for any therapeutic procedure provided that the revision is dated and signed by an authorized user prior to the administration of the dose.

If, because of the emergent nature of the patient's condition, a delay in order to provide a written directive would jeopardize the patient's health, an oral directive will be acceptable, provided that the information contained in the oral directive is documented immediately in the patient's record and a written directive is prepared within 24 hours of the oral directive.

41.3(16) General technical requirements for facilities using therapeutic radiation machines.*a.* Protection surveys.

(1) The registrant shall ensure that radiation protection surveys of all new facilities, and existing facilities not previously surveyed, are performed with an operable radiation measurement survey instrument calibrated within the past 12 months. The radiation protection survey shall be performed by, or under the direction of, a radiation therapy physicist or a certified health physicist and shall verify that, with the therapeutic radiation machine in a "BEAM-ON" condition, with the largest clinically available treatment field and with a scattering phantom in the useful beam of radiation:

1. Radiation levels in restricted areas are not likely to cause personnel exposures in excess of the limits specified in 641—subrule 40.15(1); and

2. Radiation levels in unrestricted areas do not exceed the limits specified in 641—paragraphs 40.26(1) "a" and "b."

(2) In addition to the requirements of 41.3(16) "a"(1), a radiation protection survey shall also be performed prior to medical use and:

1. After making any change in the treatment room shielding;

2. After installing or relocating of the therapeutic radiation machine;

3. Before using the therapeutic radiation machine in a manner that could result in increased radiation levels in areas outside the external beam radiation therapy treatment room.

(3) The survey record shall indicate all instances where the facility, in the opinion of the radiation therapy physicist or a certified health physicist, is in violation of applicable regulations. The survey record shall also include the date of the measurements, the reason the survey is required, the manufacturer's name, model number and serial number of the therapeutic radiation machine, the instrument(s) used to measure radiation levels, a plan of the areas surrounding the treatment room that were surveyed, the measured dose rate at several points in each area expressed in microsieverts or millirems per hour, the calculated maximum level of radiation over a period of one week for each restricted and unrestricted area, and the signature of the individual responsible for conducting the survey.

(4) If the results of the surveys required by 41.3(16) "a"(1) or (2) indicate any radiation levels in excess of the respective limit specified in 41.3(16) "a"(1), the registrant shall lock the control in the "OFF" position and not use the unit:

1. Except as may be necessary to repair, replace, or test the therapeutic radiation machine, the therapeutic radiation machine shielding, or the treatment room shielding; or

2. Until the registrant has received a specific exemption in writing from the agency.

b. Modification of radiation therapy unit or room before beginning a treatment program. If the survey required by 41.3(16) "a" indicates that an individual in an unrestricted area may be exposed to levels of radiation greater than those permitted by 641—paragraphs 40.26(1) "a" and "b," before beginning the treatment program the registrant shall:

(1) Either equip the unit with beam direction interlocks or add additional radiation shielding to ensure compliance with 641—paragraphs 40.26(1) "a" and "b";

(2) Perform the survey required by 41.3(16) "a" again; and

(3) Include in the report required by 41.3(16) "d" the results of the initial survey, a description of the modification made to comply with 41.3(5) "b"(1), and the results of the second survey; or

(4) Request and receive written authorization from the agency that authorizes radiation levels in unrestricted areas greater than those permitted by 641—paragraphs 40.26(1) "a" and "b."

c. Dosimetry equipment.

(1) The registrant shall have a calibrated dosimetry system available for use. The system shall have been calibrated by the National Institute for Standards and Technology (NIST) or by an American Association of Physicists in Medicine (AAPM) Accredited Dosimetry Calibration Laboratory (ADCL). The calibration shall have been performed within the previous 24 months and after any servicing that may have affected system calibration.

1. For beams with energies greater than 1 MV (1 MeV), the dosimetry system shall have been calibrated for Cobalt-60.

2. For beams with energies equal to or less than 1 MV (1 MeV), the dosimetry system shall have been calibrated at an energy (energy range) appropriate for the radiation being measured.

(2) The registrant shall have available for use a dosimetry system for quality assurance check measurements. To meet this requirement, the system may be compared with a system that has been calibrated in accordance with 41.3(16)“c”(1). This comparison shall have been performed within the previous 12 months and after each servicing that may have affected system calibration. The quality assurance check system may be the same system used to meet the requirement in 41.3(16)“c”(1).

(3) The registrant shall maintain a record of each dosimetry system calibration, intercomparison, and comparison for the duration of the license or registration. For each calibration, intercomparison, or comparison, the record shall include the date, the model numbers and serial numbers of the instruments that were calibrated, intercompared, or compared as required by 41.3(16)“c”(1) and (2), the correction factors that were determined, the names of the individuals who performed the calibration, intercomparison, or comparison, and evidence that the intercomparison was performed by, or under the direct supervision and in the physical presence of, a radiation therapy physicist.

d. Reports of external beam radiation therapy surveys and measurements. The registrant for any therapeutic radiation machine subject to 41.3(17) or 41.3(18) shall furnish a copy of the records required in 41.3(16)“a” and “b” to the agency within 30 days following completion of the action that initiated the record requirement.

41.3(17) Therapeutic radiation machines of less than 500 kV.

a. Equipment requirements.

(1) Leakage radiation. When the X-ray tube is operated at its maximum rated tube current for the maximum kV, the leakage air kerma rate shall not exceed the value specified at the distance specified for that classification of therapeutic radiation machine:

1. 5-50 kV systems. The leakage air kerma rate measured at any position 5 centimeters from the tube housing assembly shall not exceed 100 mrad (1 mGy) in any one hour.

2. >50 and <500 kV systems. The leakage air kerma rate measured at a distance of one meter from the target in any direction shall not exceed 1 rad (1 cGy) in any one hour. This air kerma rate measurement may be averaged over areas no larger than 100 square centimeters. In addition, the air kerma rate at a distance of 5 centimeters from the surface of the tube housing assembly shall not exceed 30 rad (30 cGy) per hour.

(2) Permanent beam-limiting devices. Permanent diaphragms or cones used for limiting the useful beam shall provide at least the same degree of attenuation as required for the tube housing assembly.

(3) Adjustable or removable beam-limiting devices.

1. All adjustable or removable beam-limiting devices, diaphragms, cones or blocks shall not transmit more than 5 percent of the useful beam for the most penetrating beam used;

2. When adjustable beam-limiting devices are used, the position and shape of the radiation field shall be indicated by a light beam.

- (4) Filter system. The filter system shall be so designed that:
 1. Filters cannot be accidentally displaced at any possible tube orientation;
 2. For equipment installed after July 9, 1997, an interlock system prevents irradiation if the proper filter is not in place;
 3. The air kerma rate escaping from the filter slot shall not exceed 1 rad (1 cGy) per hour at one meter under any operating conditions; and
 4. Each filter shall be marked as to its material of construction and its thickness.
- (5) Tube immobilization.
 1. The X-ray tube shall be so mounted that it cannot accidentally turn or slide with respect to the housing aperture; and
 2. The tube housing assembly shall be capable of being immobilized for stationary portal treatments.
- (6) Source marking. The tube housing assembly shall be so marked that it is possible to determine the location of the source to within 5 millimeters, and such marking shall be readily accessible for use during calibration procedures.
- (7) Beam block. Contact therapy tube housing assemblies shall have a removable shield of material, equivalent in attenuation to 0.5 millimeters of lead at 100 kV, which can be positioned over the entire useful beam exit port during periods when the beam is not in use.
- (8) Timer. A suitable irradiation control device shall be provided to terminate the irradiation after a preset time interval.
 1. A timer which has a display shall be provided at the treatment control panel. The timer shall have a preset time selector and an elapsed time or time remaining indicator;
 2. The timer shall be a cumulative timer which activates with an indication of "BEAM-ON" and retains its reading after irradiation is interrupted or terminated. After irradiation is terminated and before irradiation can be reinitiated, it shall be necessary to reset the elapsed time indicator;
 3. The timer shall terminate irradiation when a preselected time has elapsed, if any dose monitoring system present has not previously terminated irradiation;
 4. The timer shall permit accurate presetting and determination of exposure times as short as one second;
 5. The timer shall not permit an exposure if set at zero;
 6. The timer shall not activate until the shutter is opened when irradiation is controlled by a shutter mechanism unless calibration includes a timer error correction to compensate for mechanical lag; and
 7. Timer shall be accurate to within 1 percent of the selected value or one second, whichever is greater.
- (9) Control panel functions. The control panel, in addition to the displays required by other provisions in 41.3(6), shall have:
 1. An indication of whether electrical power is available at the control panel and if activation of the X-ray tube is possible;
 2. An indication of whether X-rays are being produced;
 3. Means for indicating X-ray tube potential and current;
 4. The means for terminating an exposure at any time;
 5. A locking device which will prevent unauthorized use of the therapeutic radiation machine; and
 6. For therapeutic radiation machines manufactured after July 9, 1997, a positive display of specific filter(s) in the beam.

(10) Multiple tubes. When a control panel may energize more than one X-ray tube:

1. It shall be possible to activate only one X-ray tube at any time;
2. There shall be an indication at the control panel identifying which X-ray tube is activated; and
3. There shall be an indication at the tube housing assembly when that tube is energized.

(11) Target-to-skin distance (TSD). There shall be a means of determining the central axis TSD to within one centimeter and of reproducing this measurement to within two millimeters thereafter.

(12) Shutters. Unless it is possible to bring the X-ray output to the prescribed exposure parameters within five seconds after the X-ray "ON" switch is energized, the beam shall be attenuated by a shutter(s) having a lead equivalency not less than that of the tube housing assembly. In addition, after the unit is at operating parameters, the shutter(s) shall be controlled by the operator from the control panel. An indication of shutter position shall appear at the control panel.

(13) Low filtration X-ray tubes. Each therapeutic radiation machine equipped with a beryllium or other low-filtration window shall be clearly labeled as such upon the tube housing assembly and shall be provided with a permanent warning device on the control panel that is activated when no additional filtration is present, to indicate that the dose rate is very high.

b. Facility design requirements for therapeutic radiation machines capable of operating in the range 50 kV to 500 kV. In addition to shielding adequate to meet requirements of 41.3(8), the treatment room shall meet the following design requirements:

(1) Aural communication. Provision shall be made for continuous two-way aural communication between the patient and the operator at the control panel.

(2) Viewing systems. Provision shall be made to permit continuous observation of the patient during irradiation and the viewing system shall be so located that the operator can observe the patient from the control panel. The therapeutic radiation machine shall not be used for patient irradiation unless at least one viewing system is operational.

(3) Additional requirements. Treatment rooms which contain a therapeutic radiation machine capable of operating above 150 kV shall meet the following additional requirements:

1. All protective barriers shall be fixed except for entrance doors or beam interceptors;
2. The control panel shall be located outside the treatment room or in a totally enclosed booth, which has a ceiling, inside the room;
3. Interlocks shall be provided such that all entrance doors, including doors to any interior booths, shall be closed before treatment can be initiated or continued. If the radiation beam is interrupted by any door opening, it shall not be possible to restore the machine to operation without closing the door and reinitiating irradiation by manual action at the control panel; and
4. When any door referred to in 41.3(17) "b"(3)"3" is opened while the radiation machine is activated, the air kerma rate at a distance of one meter from the source shall be reduced to less than 1 mGy (100 mrad) per hour.

c. Full calibration measurements.

(1) Full calibration of a therapeutic radiation machine subject to 41.3(17) shall be performed by, or under the direct supervision of, a radiation therapy physicist:

1. Before the first medical use following installation or reinstallation of the therapeutic radiation machine;
2. At intervals not exceeding one year; and

3. Before medical use under the following conditions:

- Whenever quality assurance check measurements indicate that the radiation output differs by more than 5 percent from the value obtained at the last full calibration and the difference cannot be reconciled; and

- Following any component replacement, major repair, or modification of components that could significantly affect the characteristics of the radiation beam.

4. Notwithstanding the requirements of 41.3(17)“c”(1):

- Full calibration of therapeutic radiation machines with multienergy capabilities is required only for those modes or energies that are not within their acceptable range; and

- If the repair, replacement or modification does not affect all energies, full calibration shall be performed on the affected energy that is in most frequent clinical use at the facility. The remaining energies may be validated with quality assurance check procedures against the criteria in 41.3(17)“b”(3).

(2) To satisfy the requirement of 41.3(17)“c”(1), full calibration shall include all measurements recommended for annual calibration by NCRP Report 69, “Dosimetry of X-ray and Gamma Ray Beams for Radiation Therapy in the Energy Range 10 keV to 50 MeV” (1981).

(3) The registrant shall maintain a record of each calibration for the duration of the registration. The record shall include the date of the calibration, the manufacturer’s name, model number, and serial number for both the therapeutic radiation machine and the X-ray tube, the model numbers and serial numbers of the instruments used to calibrate the therapeutic radiation machine, and the signature of the radiation therapy physicist responsible for performing the calibration.

d. Periodic quality assurance checks.

(1) Periodic quality assurance checks shall be performed on therapeutic radiation machines, subject to 41.3(6), which are capable of operation at greater than or equal to 50 kV.

(2) To satisfy the requirement of 41.3(17)“d”(1), quality assurance checks shall meet the following requirements:

1. The registrant shall perform quality assurance checks in accordance with written procedures established by the radiation therapy physicist; and

2. The quality assurance check procedures shall specify the frequency at which tests or measurements are to be performed. The quality assurance check procedures shall specify that the quality assurance check shall be performed during the calibration specified in 41.3(17)“c”(1). The acceptable tolerance for each parameter measured in the quality assurance check, when compared to the value for that parameter determined in the calibration specified in 41.3(17)“c”(1), shall be stated.

(3) The cause for a parameter exceeding a tolerance set by the radiation therapy physicist shall be investigated and corrected before the system is used for patient or human research subject irradiation;

(4) Whenever a quality assurance check indicates a significant change in the operating characteristics of a system, as specified in the radiation therapy physicist’s quality assurance check procedures, the system shall be recalibrated as required in 41.3(17)“c”(1);

(5) The registrant shall use the dosimetry system described in 41.3(16)“c”(2) to make the quality assurance check required in 41.3(17)“d”;

(6) The registrant shall have the radiation therapy physicist review and sign the results of each radiation output quality assurance check within one month of test completion;

(7) The registrant shall ensure that safety quality assurance checks of therapeutic radiation machines subject to 41.3(17) are performed at intervals not to exceed one month;

(8) Notwithstanding the requirements of 41.3(17)“d”(6) and (7), the registrant shall ensure that no therapeutic radiation machine is used to administer radiation to humans unless the quality assurance checks required by 41.3(17)“d”(6) and (7) have been performed within the 30 days prior to administration;

(9) To satisfy the requirement of 41.3(17)“d”(7), safety quality assurance checks shall ensure proper operation of:

1. Electrical interlocks at each external beam radiation therapy room entrance;
2. Proper operation of the “BEAM-ON” and termination switches;
3. Beam condition indicator lights on the access door(s), control console, and in the radiation therapy room;
4. Viewing systems;
5. If applicable, electrically operated treatment room doors from inside and outside the treatment room.

(10) The registrant shall maintain a record of each quality assurance check required by 41.3(17)“d”(1) and (7) for three years. The record shall include the date of the quality assurance check, the manufacturer’s name, model number, and serial number for the therapeutic radiation machine, the manufacturer’s name, model number and serial number of the instrument(s) used to measure the radiation output of the therapeutic radiation machine, and the signature of the individual who performed the periodic quality assurance check.

e. Operating procedures.

(1) Therapeutic radiation machines shall not be left unattended unless secured by means identified in 41.3(17)“a”(9)“5”;

(2) When a patient must be held in position for radiation therapy, mechanical supporting or restraining devices shall be used;

(3) The tube housing assembly shall not be held by an individual during operation unless the assembly is designed to require such holding and the peak tube potential of the system does not exceed 50 kV. In such cases, the holder shall wear protective gloves and apron of not less than 0.5 millimeters lead equivalency at 100 kV;

(4) A copy of the current operating and emergency procedures shall be maintained at the therapeutic radiation machine control console; and

(5) No individual other than the patient shall be in the treatment room during exposures from therapeutic radiation machines operating above 150 kV. At energies less than or equal to 150 kV, any individual, other than the patient, in the treatment room shall be protected by a barrier sufficient to meet the requirements of 641—40.26(136C).

f. Possession of survey instrument(s). Each facility location authorized to use a therapeutic radiation machine in accordance with 41.3(17) shall have at its disposal appropriately calibrated portable monitoring equipment. As a minimum, such equipment shall include a portable radiation measurement survey instrument capable of measuring dose rates over the range 1 mrem (10 μ Sv) per hour to 1000 mrem (10 mSv) per hour. The survey instrument(s) shall be operable and calibrated at intervals not to exceed 12 months for the radiation measured.

41.3(18) Therapeutic radiation machines—photon therapy systems (500 kV and above) and electron therapy systems (500 keV and above).

a. Equipment requirements.

(1) Leakage radiation outside the maximum useful beam in photon and electron modes.

1. The absorbed dose due to leakage radiation (excluding neutrons) at any point outside the maximum-sized useful beam, but within a circular plane of radius two meters which is perpendicular to and centered on the central axis of the useful beam at the nominal treatment distance (i.e., patient plane), shall not exceed a maximum of 0.2 percent and an average of 0.1 percent of the absorbed dose on the central axis of the beam at the nominal treatment distance. Measurements shall be averaged over an area not exceeding 100 square centimeters at a minimum of 16 points uniformly distributed in the plane;

2. Except for the area defined in 41.3(18) “a”(1)“1,” the absorbed dose due to leakage radiation (excluding neutrons) at one meter from the electron path between the electron source and the target or electron window shall not exceed 0.5 percent of the absorbed dose on the central axis of the beam at the nominal treatment distance. Measurements shall be averaged over an area not exceeding 100 square centimeters;

3. For equipment manufactured after July 9, 1997, the neutron absorbed dose outside the useful beam shall be in compliance with International Electrotechnical Agency (IEC) Document 601-2-1 (most current revision); and

4. For each therapeutic radiation machine, the registrant shall determine, or obtain from the manufacturer, the leakage radiation existing at the positions specified in 41.3(18) “a”(1)“1” to “3” for the specified operating conditions. Records of leakage radiation measurements shall be maintained for inspection by the agency.

(2) Leakage radiation through beam-limiting devices.

1. Photon radiation. All adjustable or interchangeable beam-limiting devices shall attenuate the useful beam such that at the nominal treatment distance, the maximum absorbed dose anywhere in the area shielded by the beam-limiting device(s) shall not exceed 2 percent of the maximum absorbed dose on the central axis of the useful beam measured in a 10-centimeter by 10-centimeter radiation field;

2. Electron radiation. All adjustable or interchangeable electron applicators shall attenuate the radiation including, but not limited to, photon radiation generated by electrons incident on the beam-limiting device and electron applicator and other parts of the radiation head, such that the absorbed dose in a plane perpendicular to the central axis of the useful beam at the nominal treatment distance shall not exceed:

- A maximum of 2 percent of the absorbed dose on the central axis of the useful beam at the nominal treatment distance. This limit shall apply beyond a line seven centimeters outside the periphery of the useful beam; and

- A maximum of 10 percent of the absorbed dose on the central axis of the useful beam at the nominal treatment distance. This limit shall apply beyond a line two centimeters outside the periphery of the useful beam.

(3) Measurement of leakage radiation.

1. Photon radiation. Measurements of leakage radiation through the beam-limiting devices shall be made with the beam-limiting devices closed and any residual aperture blocked by at least two-tenth value layers of suitable absorbing material. In the case of overlapping beam-limiting devices, the leakage radiation through each set shall be measured independently at the depth of maximum dose. Measurements shall be made using a radiation detector with an area not exceeding ten square centimeters;

2. Electron radiation. Measurements of leakage radiation through the electron applicators shall be made with the electron beam directed into the air and using a radiation detector with an area up to but not exceeding one square centimeter suitably protected against radiation which has been scattered from material beyond the radiation detector. Measurements shall be made using one centimeter of water equivalent buildup material.

(4) Filters/wedges.

1. Each wedge filter which is removable from the system shall be clearly marked with an identification number. For removable wedge filters, the nominal wedge angle shall appear on the wedge or wedge tray (if permanently mounted to the tray). If the wedge or wedge tray is significantly damaged, the wedge transmission factor shall be redetermined;

2. If the absorbed dose rate information required by 41.3(18)“a”(8) relates exclusively to operation with a field-flattening or beam-scattering filter in place, such filter shall be removable only by the use of tools;

3. For equipment manufactured after July 9, 1997, which utilizes a system of wedge filters, interchangeable field-flattening filters, or interchangeable beam-scattering foils:

- Irradiation shall not be possible until a selection of a filter or a positive selection to use “no filter” has been made at the treatment control panel, either manually or automatically;
- An interlock system shall be provided to prevent irradiation if the filter selected is not in the correct position;
- A display shall be provided at the treatment control panel showing the wedge filter(s); and
- An interlock shall be provided to prevent irradiation if any filter or beam-scattering foil selection operation carried out in the treatment room does not agree with the filter or beam-scattering foil selection operation carried out at the treatment control panel.

(5) Stray radiation in the useful beam. For equipment manufactured after July 9, 1997, the registrant shall determine during acceptance testing, or obtain from the manufacturer, data sufficient to ensure that X-ray stray radiation in the useful electron beam, absorbed dose at the surface during X-ray irradiation and stray neutron radiation in the useful X-ray beam are in compliance with International Electrotechnical Agency (IEC) Document 601-2-1 (most current revision).

(6) Beam monitors. All therapeutic radiation machines subject to 41.3(18) shall be provided with redundant beam monitoring systems. The sensors for these systems shall be fixed in the useful beam during treatment to indicate the dose monitor unit rate.

1. Equipment manufactured after July 9, 1997, shall be provided with at least two independently powered integrating dose meters. Alternatively, common elements may be used if the production of radiation is terminated upon failure of any common element.

2. Equipment manufactured on or before July 9, 1997, shall be provided with at least one radiation detector. This detector shall be incorporated into a useful beam monitoring system. The detector and the system into which that detector is incorporated shall meet the following requirements:

- Each detector shall be removable only with tools and, if movable, shall be interlocked to prevent incorrect positioning;
- Each detector shall form part of a beam monitoring system from whose readings in dose monitor units the absorbed dose at a reference point can be calculated;
- Each beam monitoring system shall be capable of independently monitoring, interrupting, and terminating irradiation; and

3. For equipment manufactured after July 9, 1997, the design of the beam monitoring systems shall ensure that the:

- Malfunctioning of one system shall not affect the correct functioning of the other system(s); and
- Failure of any element common to both systems which could affect the correct function of both systems shall terminate irradiation or prevent the initiation of radiation.

4. Each beam monitoring system shall have a legible display at the treatment control panel. For equipment manufactured after July 9, 1997, each display shall:

- Maintain a reading until intentionally reset;
- Have only one scale and no electrical or mechanical scale multiplying factors;
- Utilize a design such that increasing dose is displayed by increasing numbers; and
- In the event of power failure, the beam monitoring information required in 41.3(18) "a"(6)"4" displayed at the control panel at the time of failure shall be retrievable in at least one system for a 20-minute period of time.

(7) Beam symmetry.

1. Bent-beam linear accelerators subject to 41.3(18) shall be provided with auxiliary device(s) to monitor beam symmetry;

2. The device(s) referenced in 41.3(18) "a"(7)"1" shall be able to detect field asymmetry greater than 10 percent, and shall be configured to terminate irradiation if the specifications in 41.3(18) "a"(7)"2" cannot be maintained.

(8) Selection and display of dose monitor units.

1. The preselected number of dose monitor units shall be displayed at the treatment control panel until reset manually;

2. After termination of irradiation, it shall be necessary to reset the dosimeter display before subsequent treatment can be initiated; and

3. For equipment manufactured after July 9, 1997, after termination of irradiation, it shall be necessary for the operator to reset the preselected dose monitor units before irradiation can be initiated.

(9) Air kerma rate/absorbed dose rate. For equipment manufactured after July 9, 1997, a system shall be provided from whose readings the air kerma rate or absorbed dose rate at a reference point can be calculated. (The radiation detectors specified in 41.3(18) "a"(6) may form part of this system.) In addition:

1. The dose monitor unit rate shall be displayed at the treatment control panel;

2. If the equipment can deliver under any conditions an air kerma rate or absorbed dose rate at the nominal treatment distance more than twice the maximum value specified by the manufacturer, a device shall be provided which terminates irradiation when the air kerma rate or absorbed dose rate exceeds a value twice the specified maximum. The dose rate at which the irradiation will be terminated shall be a record maintained by the registrant;

3. If the equipment can deliver under any fault condition(s) an air kerma rate or absorbed dose rate at the nominal treatment distance more than ten times the maximum value specified by the manufacturer, a device shall be provided to prevent the air kerma rate or absorbed dose rate anywhere in the radiation field from exceeding twice the specified maximum value and to terminate irradiation if the excess absorbed dose at the nominal treatment distance exceeds 400 rad (4 Gy); and

4. For each therapeutic radiation machine, the registrant shall determine, or obtain from the manufacturer, the maximum value(s) specified in 41.3(18) "a"(7)"2" and "3" for the specified operating conditions. Records of these maximum value(s) shall be maintained at the installation for inspection by the agency.

(10) Termination of irradiation by the beam monitoring system or systems during stationary beam radiation therapy.

1. Each primary system shall terminate irradiation when the preselected number of dose monitor units has been detected by the system;

2. If the original design of the equipment included a secondary dose monitoring system, that system shall be capable of terminating irradiation when not more than 15 percent or 40 dose monitor units above the preselected number of dose monitor units set at the control panel has been detected by the secondary dose monitoring system; and

3. For equipment manufactured after July 9, 1997, an indicator on the control panel shall show which monitoring system has terminated irradiation.

(11) Termination switches. It shall be possible to terminate irradiation and equipment movement or go from an interruption condition to termination condition at any time from the operator's position at the treatment control panel.

(12) Interruption switches. If a therapeutic radiation machine has an interrupt mode, it shall be possible to interrupt irradiation and equipment movements at any time from the treatment control panel. Following an interruption it shall be possible to restart irradiation by operator action without any re-selection of operating conditions. If any change of a preselected value is made during an interruption, irradiation and equipment movements shall be automatically terminated.

(13) Timer. A suitable irradiation control device shall be provided to terminate the irradiation after a preset time interval.

1. A timer shall be provided which has a display at the treatment control panel. The timer shall have a preset time selector and an elapsed time indicator;

2. The timer shall be a cumulative timer which activates with an indication of "BEAM-ON" and retains its reading after irradiation is interrupted or terminated. After irradiation is terminated and before irradiation can be reinitiated, it shall be necessary to reset the elapsed time indicator;

3. The timer shall terminate irradiation when a preselected time has elapsed, if the dose monitoring systems have not previously terminated irradiation.

(14) Selection of radiation type. Equipment capable of both X-ray therapy and electron therapy shall meet the following additional requirements:

1. Irradiation shall not be possible until a selection of radiation type (X-rays or electrons) has been made at the treatment control panel;

2. The radiation type selected shall be displayed at the treatment control panel before and during irradiation;

3. An interlock system shall be provided to ensure that the equipment can principally emit only the radiation type which has been selected;

4. An interlock system shall be provided to prevent irradiation with X-rays, except to obtain a verification image, when electron applicators are fitted;

5. An interlock system shall be provided to prevent irradiation with electrons when accessories specific for X-ray therapy are fitted; and

6. An interlock system shall be provided to prevent irradiation if any selected operations carried out in the treatment room do not agree with the selected operations carried out at the treatment control panel.

(15) Selection of energy. Equipment capable of generating radiation beams of different energies shall meet the following requirements:

1. Irradiation shall not be possible until a selection of energy has been made at the treatment control panel;

2. The nominal energy value selected shall be displayed at the treatment control panel before and during irradiation; and

3. Irradiation shall not be possible until the appropriate flattening filter or scattering foil for the selected energy is in its proper location.

(16) Selection of stationary beam radiation therapy or moving beam radiation therapy. Therapeutic radiation machines capable of both stationary beam radiation therapy and moving beam radiation therapy shall meet the following requirements:

1. Irradiation shall not be possible until a selection of stationary beam radiation therapy or rotational arc radiation therapy has been made at the treatment control panel;

2. The mode of operation shall be displayed at the treatment control panel;

3. An interlock system shall be provided to ensure that the equipment can operate only in the mode which has been selected;

4. An interlock system shall be provided to prevent irradiation if any selected parameter in the treatment room does not agree with the selected parameter at the treatment control panel;

5. Moving beam radiation therapy shall be controlled to obtain the selected relationships between incremental dose monitor units and incremental movement. For equipment manufactured after July 9, 1997:

- An interlock system shall be provided to terminate irradiation if the number of dose monitor units delivered in any ten degrees of rotation differs by more than 20 percent from the selected value;

- Where angle terminates the irradiation in moving beam radiation therapy, the dose monitor units delivered shall differ by less than 5 percent from the dose monitor unit value selected;

- An interlock shall be provided to prevent motion of more than five degrees beyond the selected limits during moving beam radiation therapy;

- An interlock shall be provided to require that a selection of direction be made at the treatment control panel in all units which are capable of both clockwise and counterclockwise moving beam radiation therapy.

- Moving beam radiation therapy shall be controlled with both primary position sensors and secondary position sensors to obtain the selected relationships between incremental dose monitor units and incremental movement.

6. Where the beam monitoring system terminates the irradiation in moving beam radiation therapy, the termination of irradiation shall be as required by 41.3(18)“a”(10); and

7. For equipment manufactured after July 9, 1997, an interlock system shall be provided to terminate irradiation if movement:

- Occurs during stationary beam radiation therapy; or

- Does not start or stops during moving beam radiation therapy unless such stoppage is a pre-planned function.

b. Facility design requirements for therapeutic radiation machines operating above 500 kV. In addition to shielding adequate to meet requirements of 41.3(19), the following design requirements are made:

(1) Protective barriers. All protective barriers shall be fixed, except for access doors to the treatment room or movable beam interceptors.

(2) Control panel. In addition to other requirements specified in 41.3(136C), the control panel shall also:

1. Be located outside the treatment room;

2. Provide an indication of whether electrical power is available at the control panel and if activation of the radiation is possible;

3. Provide an indication of whether radiation is being produced; and
4. Include an access control (locking) device which will prevent unauthorized use of the therapeutic radiation machine.

(3) Viewing systems. Windows, mirrors, closed-circuit television or an equivalent viewing system shall be provided to permit continuous observation of the patient following positioning and during irradiation and shall be so located that the operator may observe the patient from the treatment control panel. The therapeutic radiation machine shall not be used for patient irradiation unless at least one viewing system is operational.

(4) Aural communications. Provision shall be made for continuous two-way aural communication between the patient and the operator at the control panel. The therapeutic radiation machine shall not be used for irradiation of patients unless continuous two-way aural communication is possible.

(5) Room entrances. Treatment room entrances shall be provided with warning lights in a readily observable position near the outside of all access doors, which will indicate when the useful beam is "ON" and when it is "OFF".

(6) Entrance interlocks. Interlocks shall be provided such that all access controls are activated before treatment can be initiated or continued. If the radiation beam is interrupted by any access control, it shall not be possible to restore the machine to operation without resetting the access control and reinitiating irradiation by manual action at the control panel.

(7) Beam interceptor interlocks. If the shielding material in any protective barrier requires the presence of a beam interceptor to ensure compliance with 641—paragraphs 40.26(1)"a" and "b," interlocks shall be provided to prevent the production of radiation, unless the beam interceptor is in place, whenever the useful beam is directed at the designated barrier(s).

(8) Emergency cutoff switches. At least one emergency power cutoff switch shall be located in the radiation therapy room and shall terminate all equipment electrical power including radiation and mechanical motion. This switch is in addition to the termination switch required by 41.3(18)"a"(11). All emergency power cutoff switches shall include a manual reset so that the therapeutic radiation machine cannot be restarted from the unit's control console without resetting the emergency cutoff switch.

(9) Safety interlocks. All safety interlocks shall be designed so that any defect or component failure in the safety interlock system prevents or terminates operation of the therapeutic radiation machine.

(10) Surveys for residual radiation. Surveys for residual activity shall be conducted on all therapeutic radiation machines capable of generating photon and electron energies above 10 MV prior to machining, removing, or working on therapeutic radiation machine components which may have become activated due to photoneutron production.

(11) Possession of survey instrument(s). Each facility location authorized to use a therapeutic radiation machine in accordance with 41.3(18) shall have at its disposal appropriately calibrated portable monitoring equipment. As a minimum, such equipment shall include a portable radiation measurement survey instrument capable of measuring dose rates over the range 1 mrem (10 μ Sv) per hour to 1000 mrem (10 mSv) per hour. The survey instrument(s) shall be operable and calibrated at intervals not to exceed 12 months for the radiation measured.

c. Radiation therapy physicist support.

(1) The services of a radiation therapy physicist shall be required in facilities having therapeutic radiation machines with energies of 500 kV and above. The radiation therapy physicist shall be responsible for:

1. Full calibration(s) required by 41.3(18)"e" and protection surveys required by 41.3(16)"a";
2. Supervision and review of dosimetry;
3. Beam data acquisition and transfer for computerized dosimetry, and supervision of its use;
4. Quality assurance, including quality assurance check review required by 41.3(18)"f"(5) of these regulations;
5. Consultation with the authorized user in treatment planning, as needed; and

6. Performing calculations/assessments regarding misadministrations.

(2) If the radiation therapy physicist is not a full-time employee of the registrant, the operating procedures required by 41.3(18) "d" shall also specifically address how the radiation therapy physicist is to be contacted for problems or emergencies, as well as the specific actions, if any, to be taken until the radiation therapy physicist can be contacted.

d. Operating procedures.

(1) No individual, other than the patient, shall be in the treatment room during treatment or during any irradiation for testing or calibration purposes;

(2) Therapeutic radiation machines shall not be made available for medical use unless the requirements of 41.3(16) "a," 41.3(18) "e," and 41.3(18) "f" have been met;

(3) Therapeutic radiation machines, when not in operation, shall be secured to prevent unauthorized use;

(4) When adjustable beam-limiting devices are used, the position and shape of the radiation field shall be indicated by a light field;

(5) If a patient must be held in position during treatment, mechanical supporting or restraining devices shall be used; and

(6) A copy of the current operating and emergency procedures shall be maintained at the therapeutic radiation machine control console.

e. Full calibration measurements.

(1) Full calibration of a therapeutic radiation machine subject to 41.3(18) shall be performed by, or under the direct supervision of, a radiation therapy physicist:

1. Before the first medical use following installation or reinstallation of the therapeutic radiation machine;

2. At intervals not to exceed 12 months; and

3. Before medical use under the following conditions:

- Whenever quality assurance check measurements indicate that the radiation output differs by more than 5 percent from the value obtained at the last full calibration and the difference cannot be reconciled; and

- Following any component replacement, major repair, or modification of components that could significantly affect the characteristics of the radiation beam.

4. Notwithstanding the requirements of 41.3(18) "e"(1) "3":

- Full calibration of therapeutic radiation machines with multienergy or multimode capabilities is required only for those modes or energies that are not within their acceptable range; and

- If the repair, replacement or modification does not affect all modes or energies, full calibration shall be performed on the effected mode/energy that is in most frequent clinical use at the facility. The remaining energies/modes may be validated with quality assurance check procedures against the criteria in 41.3(18) "e"(1) "3."

(2) To satisfy the requirement of 41.3(18) "e"(1), full calibration shall include all measurements required for annual calibration by Appendix F of 641—Chapter 41.

(3) The registrant shall use the dosimetry system described in 41.3(16) "c" to measure the radiation output for one set of exposure conditions. The remaining radiation measurements required in 41.3(18) "e"(2) may then be made using a dosimetry system that indicates relative dose rates; and

(4) The registrant shall maintain a record of each calibration for the duration of the registration. The record shall include the date of the calibration, the manufacturer's name, model number, and serial number for the therapeutic radiation machine, the model numbers and serial numbers of the instruments used to calibrate the therapeutic radiation machine, and the signature of the radiation therapy physicist responsible for performing the calibration.

f. Periodic quality assurance checks.

(1) Periodic quality assurance checks shall be performed on all therapeutic radiation machines subject to 41.3(18) at intervals not to exceed one week;

(2) To satisfy the requirement of 41.3(18)"*f*"(1), quality assurance checks shall include determination of central axis radiation output and a representative sampling of periodic quality assurance checks contained in Appendix F of 641—Chapter 41. Representative sampling shall include all referenced periodic quality assurance checks at intervals not to exceed 12 consecutive calendar months;

(3) The registrant shall use a dosimetry system which has been compared within the previous 12 months with the dosimetry system described in 41.3(16)"*c*"(1) to make the periodic quality assurance checks required in 41.3(18)"*f*"(2);

(4) The registrant shall perform periodic quality assurance checks required by 41.3(18)"*f*"(1) in accordance with procedures established by the radiation therapy physicist;

(5) The registrant shall review the results of each periodic radiation output check according to the following procedures:

1. The authorized user and radiation therapy physicist shall be immediately notified if any parameter is not within its acceptable tolerance. The therapeutic radiation machine shall not be made available for subsequent medical use until the radiation therapy physicist has determined that all parameters are within their acceptable tolerances;

2. If all quality assurance check parameters appear to be within their acceptable range, the quality assurance check shall be reviewed and signed by either the authorized user or radiation therapy physicist within two weeks of treatment; and

3. The radiation therapy physicist shall review and sign the results of each radiation output quality assurance check within two weeks of completion.

(6) Therapeutic radiation machines subject to 41.3(18) shall have safety quality assurance checks of each external beam radiation therapy machine performed at intervals not to exceed one week;

(7) To satisfy the requirement of 41.3(18)"*f*"(6), safety quality assurance checks shall ensure proper operation of:

1. Electrical interlocks at each external beam radiation therapy room entrance;

2. Proper operation of the "BEAM-ON," interrupt and termination switches;

3. Beam condition indicator lights on the access doors, control console, and in the radiation therapy room;

4. Viewing systems;

5. Aural systems;

6. Electrically operated treatment room door(s) from inside and outside the treatment room;

(8) Emergency power cutoff switches shall be checked for proper operation at intervals not to exceed three months. If more than one emergency power cutoff switch is installed and not all switches are tested at once, each switch shall be tested on a rotating basis. Safety quality assurance checks of the emergency power cutoff switches may be conducted at the end of the treatment day in order to minimize possible stability problems with the therapeutic radiation machine;

(9) The registrant shall promptly repair any system identified in 41.3(18)"*f*"(7) that is not operating properly; and

(10) The registrant shall maintain a record of each quality assurance check required by 41.3(18)“f”(1) and 41.3(18)“f”(7) for three years. The record shall include the date of the quality assurance check, the manufacturer’s name, model number, and serial number for the therapeutic radiation machine, the manufacturer’s name, model number and serial number of the instrument(s) used to measure the radiation output of the therapeutic radiation machine, and the signature of the individual who performed the periodic quality assurance check.

41.3(19) Shielding and safety design requirements.

a. Each therapeutic radiation machine subject to 41.3(17) or 41.3(18) shall be provided with such primary or secondary barriers as are necessary to ensure compliance with 641—40.15(136C) and 641—40.26(136C).

b. Facility design information for all new installations of a therapeutic radiation machine or installations of a therapeutic radiation machine of higher energy into a room not previously approved for that energy shall be submitted for agency approval prior to actual installation of the therapeutic radiation machine. The minimum facility design information that must be submitted is contained in Appendix G of 641—Chapter 41.

641—41.4(136C) Radiation safety requirements for analytical X-ray equipment. Rescinded IAB 4/8/98, effective 7/1/98.

641—41.5(136C) Radiation safety requirements for wireline service operations and subsurface tracer studies. Rescinded IAB 4/8/98, effective 7/1/98.

641—41.6(136C) X-ray machines used for screening and diagnostic mammography.

41.6(1) Definitions. In addition to the definitions provided in 41.1(136C), the following definitions shall be applicable to this rule.

“*Artifact*” means a substance or structure not naturally present in living tissue but of which an authentic image appears in a radiograph.

“*Automatic exposure control systems*” means automatic exposure control systems, often referred to as phototimers, which are designed to automatically determine and provide the exposure needed to produce an adequate density image by sampling the X-ray intensity after passage through the patient and image receptor.

“*Average glandular dose*” means the energy deposited per unit mass of glandular tissue averaged over all the glandular tissue in the breast, calculated from values of entrance exposure in air, the X-ray beam quality (half-value layer), and compressed breast thickness. The maximum average glandular dose should be 6 milliGray (0.6 rad) or less for a 2-view examination of the breast. See also: “Dose.”

“*Base density*” means the optical density due to the supporting base of the film alone. The base density of a film is the optical density that would result if an unexposed film were processed through the fixer, wash, and dryer, without first passing through the developer.

“*Base plus fog density*” means the optical density of a film due to its base density plus any action of the developer on the unexposed silver halide crystals. The base plus fog density can be measured by processing an unexposed film through the entire processing cycle and measuring the resultant optical density.

“*Cassette*” means a light-tight case, usually made of thin, low X-ray absorption plastic, for holding X-ray film. One or two intensifying screens for the conversion of X-rays to visible light photons are mounted inside the cassette so that they are in close contact to the film.

“*Compression device*” means a firm plastic paddle used to help hold the breast stationary and eliminate blurring due to motion, to help separate structures within the breast, and to decrease the thickness of breast tissue, minimizing the amount of radiation used and the amount of scattered radiation reaching the film.

“*Control chart*” means a chart used to record (and control) the results of quality control testing as a function of time.

“*Control limit*” means the range of variation on a control chart beyond which action must be taken to correct the results of quality control testing.

“*Craniocaudal view*” means one of two routine views for mammography. The detector system is placed caudad to (below) the breast and the vertical X-ray beam is directed from cranial to caudad (downward) through the breast.

“*Dedicated mammography equipment*” means X-ray systems designed specifically for breast imaging, providing optimum imaging geometry, a device for breast compression and low dose exposure that can generate reproducible images of high quality.

“*Densitometer*” means an instrument which measures the degree of blackening (or radiographic density) of film due to radiation or light by measuring the ratio of the light intensity incident on the film to the light intensity transmitted by the film.

“*Detents*” means mechanical settings that limit or prevent the motion or rotation of an X-ray tube, cassette assembly, or image receptor system.

“*Developer*” means a chemical solution (alkaline) that changes the latent image (exposed silver halide crystals) on a film to a visible image composed of minute masses of black metallic silver.

“*Developer replenishment*” means the process, occurring as film travels past a certain point in the processor, triggering the activation of a pump, whereby fresh developer is added in small amounts to the solution in the developer tank of the processor. The purpose is to maintain the proper alkalinity, chemical activity, and level of solution in the developer tank.

“*Diagnostic mammography*” means mammography performed on an individual who, by virtue of symptoms or physical findings, is considered to have a substantial likelihood of having breast disease.

“*Dose*” means the amount of energy deposited per unit mass of tissue due to X-radiation. The newer unit of absorbed dose is the Gray: 1 Gray=1 Joule of energy deposited per kilogram of tissue. The older unit of absorbed dose is the rad: 1 rad=0.01 Gray, 1 centiGray, or 10 milliGray.

“*Exposure*” means the amount of X-radiation, quantitated by measuring the amount of ionization in air caused by the radiation. The units of exposure are Coulombs of charge ionized per kilogram of air. The older unit of exposure is the Roentgen: 1 Roentgen= 2.58×10^{-4} Coulombs of charge per kilogram of air.

“*Fixer*” means a chemical solution (acidic) which removes the unexposed and undeveloped silver halide crystals from film so it will not discolor or darken with age or exposure to light. Fixer also hardens the gelatin containing the black metallic silver so film may be dried and resist damage from abrasions.

“*Fixer retention*” means the inadequate removal of fixer from the film by the water in the wash tank of the processor. Retained fixer causes eventual brown discoloration of the radiograph.

“*Focal spot size*” means the focal spot is the area of the target or anode that is bombarded by electrons from the cathode of the X-ray tube to produce X-rays. The smaller the focal spot, the better the limited spatial resolution of the X-ray system, especially in magnification mammography.

“*Fog*” means the density added to a radiograph due to unwanted action of the developer on the unexposed silver halide crystals or by light, radiation, or heat exposure during storage, handling, and processing.

“*Grids*” means a set of thin lead strips spaced close to one another, interspaced by carbon fiber for mammographic grids. The grid is placed between the breast and the screen-film image receptor to reduce scattered radiation reaching the image receptor.

“*Half-value layer (HVL)*” means the thickness of a specified substance which, when introduced into the path of a given beam of radiation, reduces the exposure rate by one-half. HVL is a measure of beam quality and is usually specified in millimeters of aluminum for diagnostic units.

“*Image contrast*” means the amount of radiographic density difference between adjacent areas resulting from a fixed amount of attenuation difference or light exposure difference.

“*Image noise.*” See “Radiographic noise.”

“*Image quality*” means the overall clarity and detail of a radiographic image. Limiting spatial resolution (or resolving power), image sharpness, and image contrast are three common measures of image quality.

“*Image sharpness*” means the overall impression of detail and clarity in a radiographic image.

“*Kilovoltage, peak (kVp)*” means the maximum potential difference setting between anode and cathode in an X-ray tube. This setting is also the maximum energy of X-rays emitted by the X-ray tube in kilo-electron volts (keV).

“*Mediolateral view*” means one of the routine views for mammography in addition to the cranio-caudal view. The detector system is placed lateral to the breast and the horizontal X-ray beam is directed from medial to lateral aspect through the breast.

“*Milliamperage (mA) setting*” means the current of electrons passing from cathode to anode in an X-ray tube. For a fixed kVp, the output of X-rays per unit time from the tube is linearly proportional to the mA setting.

“*Milliamperage-seconds (mAs)*” means the product of electron current (mA) and the time over which an X-ray exposure is made (in seconds). For a fixed kVp, total X-ray output is linearly proportional to mAs.

“*Oblique mediolateral view*” means one of the standard two views of the breast. The detector system (cassette holder assembly) is angled 30-60 degrees from horizontal so that the cassette assembly is parallel to the pectoral muscle and the corner of the cassette holder fits comfortably into the axilla. The X-ray beam is directed from the supero-medial to the infero-lateral aspect of the breast.

“*Phantom*” means an artificial test object which simulates the average composition of and various structures within the breast. A “good breast phantom” should have an established correlation with clinical image quality, allowing objective rather than subjective analysis, and should be sensitive to small changes in mammographic image quality.

“*Physician consultant*” means a licensed doctor of medicine or osteopathy who meets the requirements for the interpreting physician as specified in 41.6(3)“b” and who is responsible for the operation of the mammography program. This individual is designated by the supplier.

“*Processor*” means an automated device which transports film in a controlled manner by a system of rollers through specialized sections where developing, fixing, washing, and drying of the film occur.

“*Quality assurance*” means the overall program of testing and maintaining the highest possible standards of quality in the acquisition and interpretation of radiographic images.

“Quality control” means the actual process of testing and maintaining the highest possible standards of quality in equipment performance and the acquisition and interpretation of radiographic images.

“Quality control technologist” means the technologist assigned the task of testing for and maintaining records of radiographic image quality.

“Radiographic contrast” means the magnitude of optical density difference between structures of interest and their surroundings, or between areas of film receiving different amounts of X-ray or visible light exposure.

“Radiographic noise” means unwanted fluctuations in optical density on the screen-film image.

“Radiographic sharpness” means the distinctness or perceptibility of the boundary or edge of the structure in a mammogram.

“Repeat (or reject) analysis” means a systematic approach to determine the causes for radiographs being discarded or repeated, or both.

“Replenishment rate” means the amount of chemicals added in order to maintain the proper chemical activity of developer and fixer solutions.

“Safelight” means a source of minimal visible light in a darkroom, produced at frequencies (colors) to which the film is insensitive, protecting the film from unwanted exposure (fog) while allowing personnel to function more efficiently and safely.

“Screen” means microscopic phosphor crystals on a plastic support and used in conjunction with either single or double emulsion film; the screen emits visible light when exposed to X-radiation, creating a latent image on X-ray film.

“Screen-film combination” means a particular intensifying screen used with a particular type of film. Care must be taken to match the number of screens (one or two) to the number of emulsions coating the film and to match the light output spectrum of the screen to the light sensitivity of the film.

“Screen-film contact” means the close proximity of the intensifying screen to the emulsion of the film, necessary in order to achieve a sharp image on the film.

“Screen-film mammography” means mammography performed with high-detailed intensifying screen(s) in close contact with the film.

“Screening mammography” means X-ray breast examination of asymptomatic individuals in an attempt to detect breast cancer when it is small, nonpalpable, and confined to the breast.

“Sensitometer” means a device used to reproducibly expose a piece of film to a number of different levels of light intensity.

“Sensitometric strip” means a sheet of film exposed by a sensitometer, resulting in a gray scale range. Such strips are used to measure the range of densities, from minimum to maximum, resulting from a reproducible set of exposures.

“Sensitometry” means a quantitative measurement of the response of film to exposure and development. Sensitometry is used to test the processor setup and stability.

“Supplier” means the individual in control of a mammography facility whose basic responsibility is the overall quality of all mammograms conducted in that particular facility.

“Thermoluminescent dosimeter (TLD)” means a radiation dose measurement device using a crystalline substance (chips or powder) that, when properly prepared (annealed) and exposed to radiation, emits light in proportion to the radiation dose received.

“Viewbox” means a device by which a uniform field of white light is transmitted through an X-ray so that the image on the film may be seen.

“Written report” means interpreting physician’s technical narrative of a mammography evaluation.

“Written statement” means interpreting physician’s description of a mammography examination written in lay terms.

41.6(2) *Registration and application standards and requirements.*

a. Each radiation machine used to perform mammography shall be registered according to 641—subrule 39.3(2).

b. Each facility wishing to perform mammography shall apply for agency authorization by providing or verifying the following information for each mammography machine:

(1) The mammography unit meets the criteria for the American College of Radiology (ACR) mammography accreditation. An evaluation report issued by the American College of Radiology meets this requirement.

(2) The mammography equipment and facility meet the general requirements of these rules for radiation machines.

(3) The radiation machine is specifically designed to perform mammography.

(4) The radiation machine is used according to these rules on patient radiation exposure and radiation dose levels.

(5) The radiation machine is operated by individuals meeting the requirements of this subrule.

(6) The entire mammography system is evaluated annually by a radiation physicist.

(7) The equipment, personnel, procedures, and records are evaluated annually by a physician consultant.

c. Withdrawal or denial of mammography authorization.

(1) Mammography authorization may be withdrawn with cause if any machine does not meet one or more of the standards of these rules.

(2) The facility shall have opportunity for a hearing in connection with a denial or withdrawal of mammography authorization.

(3) An emergency order withdrawing authorization may be issued if the agency finds the radiation unit or facility violates rules that seriously affect the health, safety, and welfare of the public. An opportunity for hearing shall be held within five working days after the issuance of the order. The order shall be effective during the proceedings.

(4) If authorization is withdrawn, the radiation machine shall not be used for mammography until reinstated.

d. Reinstatement of mammography authorization.

(1) An application for reinstatement shall be submitted and processed the same as an initial application.

(2) The agency shall inspect the radiation machine within 60 days of the approved reinstatement application.

(3) A certificate of reinstatement shall be issued only after the agency has inspected the radiation machine and determined that it meets the requirements of these rules.

e. Inspections. The agency shall conduct an inspection of each radiation machine no later than 60 days after initial mammography authorization and at least annually thereafter.

f. Determination of the quality of the mammograms produced by facilities. To make the determination each facility will:

(1) Provide at the time of initial registration and at renewal (at least every three years) thereafter, two original (not copies) mammography examinations which meet the following criteria:

1. One mammography examination, including craniocaudal and mediolateral oblique views of each breast, of a patient with fatty breasts,

2. One mammography examination, including craniocaudal and mediolateral oblique views of each breast, of a patient with at least 75 percent glandular tissue, and

3. Each mammography examination must have been interpreted as a "normal" examination.

(2) Provide randomly (at least every three years), at the request of agency mammography inspectors, two mammography examinations (mammograms) which meet the criteria in 41.6(2)“f”(1).

(3) Have the film returned by the agency for inclusion in the patient’s file after quality interpretation by agency radiologists.

(4) Be billed the fee for the quality interpretation as set forth in 641—38.8(1)“b”(2).

(5) Be provided with a written explanation of the results of the quality evaluation which will accompany the returned mammograms referred to in 41.6(2)“f”(3).

41.6(3) Mammography personnel.

a. Physician consultant.

(1) Must be available either on staff or through arrangement.

(2) Must document in writing annually completion of:

1. Review of the procedural manuals to determine that they are adequate.

2. Verification that equipment and personnel meet applicable state requirements and are performing properly.

3. Verification that the safety procedures are being followed.

4. Verification that all other requirements of these rules are being met.

b. Interpreting physician. All mammograms must be interpreted by a radiologist who meets the following certification, experience, continuing education, and written report requirements:

(1) Be certified by the American Board of Radiology, the American Osteopathic Board of Radiology, or Royal College of Physicians and Surgeons of Canada in Radiology or have had at least two months of documented full-time training from a person recognized by this agency. The training must include interpretation of mammograms, including instructions in radiation physics, radiation effects and radiation protection.

(2) Has interpreted an average of ten or more mammograms per workweek in the prior six months or has completed a radiology residency within the past two years.

(3) Has successfully completed or taught a minimum of 40 hours (includes radiology residency) of postgraduate instruction in mammography interpretation.

(4) Has successfully completed or taught a minimum of 15 hours of postgraduate instruction in mammography interpretation every 36 months thereafter.

(5) Continues to interpret an average of ten or more mammograms per workweek.

(6) Signs a written report, as defined in 41.6(1), a copy of which must be sent to the referring physician or, if a referring physician is not available, directly to the patient.

(7) Provides a copy of the written report and the original images or films to the patient’s mammography supplier for inclusion in the patient’s medical record.

(8) Provides a written statement to the patient, either through a referring physician or designee or, if a referring physician is not available, directly to the patient. The statement must:

1. Be written in terms easily understood by a lay person.

2. Describe the test results and the importance of the mammogram to the patient’s health (including, if the results are positive, a description of the next steps), as well as the patient’s responsibility to share with any new physician or supplier of the next mammogram, the date and place of the previous mammogram.

3. Record the date of the procedure, name of the facility, and the name of the physician, if any, to whom the patient wants a copy to be sent.

4. Indicate that the original images of films are being provided to the mammographic supplier, for inclusion in the patient’s medical record.

c. *Mammography imaging medical physicist.* All mammography imaging medical physicists conducting surveys of mammography facilities and providing oversight of the facility quality assurance program under the federal "Mammography Quality Standards Act of 1992" (MQSA) shall meet the requirements for initial qualifications as well as the requirements for continuing qualifications.

(1) Initial qualifications. All mammography imaging medical physicists shall be state-approved or be certified by the American Board of Radiology in Radiological Physics/Diagnostic Radiological Physics, the American Board of Medical Physics in Diagnostic Imaging Physics, or the Canadian College of Physicists in Medicine as a Fellow in Diagnostic Radiological Physics or any other body approved by FDA to certify medical physicists; and

1. Have a master's or higher degree in a science from a college or university accredited by one of the regional accreditation bodies of the Commission on Higher Education with not less than 30 semester hours or equivalent of college level physics or radiation science, have two years of experience in conducting performance evaluations of mammography facilities and 20 hours of documented specialized training in conducting performance evaluations of mammography facilities. Complete surveys of five mammography units shall be equal to one year of experience. Two or more years of training while pursuing a master's or higher degree in medical physics may be accepted in lieu of one year of experience. After April 28, 1999, the experience shall be acquired under the direct supervision of a mammography imaging medical physicist who meets the requirements in 41.6(3)"c"(1) and 41.6(3)"c"(2).

2. Prior to October 27, 1997, have a bachelor's degree in a physical science from a college or university accredited by one of the regional accreditation bodies of the Commission on Higher Education with not less than 15 semester hours or equivalent college level physics or radiation sciences and five years of experience in conducting performance evaluations of mammography facilities. The individual shall have surveyed at least five mammography units in each of the five years and have at least 40 hours of documented specialized training in conducting performance evaluations of mammography facilities to comply with the requirements of MQSA.

(2) Continuing qualifications.

1. Continuing education. After the third anniversary of completion of the requirements of 41.6(3)"c"(1), the individual shall have taught or completed at least 15 continuing education units in mammographic imaging over the three previous years. This shall include training, if available, appropriate to each mammographic modality evaluated by the mammography imaging medical physicist during the surveys or oversights of quality assurance programs for which the medical physicist is responsible.

2. Continuing experience. After the first anniversary of completion of the requirements of 41.6(3)"c"(1), and each year thereafter, the individual shall have surveyed at least three mammography units within the last 12 months. This requirement does not apply to an individual who is employed full-time at a single facility as a diagnostic medical physicist.

(3) All facility survey reports must be signed by a mammography imaging medical physicist who meets the qualification requirements of 41.6(3)"c"(1).

(4) A mammography imaging medical physicist who signs a facility survey report must have been present in that facility during the survey.

(5) Mammography imaging medical physicists who fail to maintain the required continuing qualifications stated in 41.6(3)“c”(2) shall reestablish their qualifications before independently surveying another facility. To reestablish their qualifications, mammography imaging medical physicists who fail to meet the continuing education requirement of 41.6(3)“c”(2) must obtain a sufficient number of continuing education units to bring their total up to the required 15 in the previous three years. Mammography imaging medical physicists who fail to meet the continuing experience requirement of 41.6(3)“c”(1) must obtain experience by surveying one mammography unit for each year of not meeting the continuing experience requirements under the supervision of a mammography imaging medical physicist who meets the qualifications stated in 41.6(3)“c”(1) and 41.6(3)“c”(2). After five years of not meeting the continuing experience requirements, the mammography imaging medical physicist must requalify under 41.6(3)“c”(1).

d. Equipment operators. Any individual operating mammography equipment must be a physician as defined in 641—Chapter 38 or must be credentialed as a general radiographer as set forth in 641—Chapter 42.

(1) Each general radiographer must meet one of the following:

1. Have successfully completed a formal training program in radiologic technology in a school that meets the requirements of Appendix A (Standards for Accreditation of Educational Programs for Radiographers) of 42 CFR Part 75; or

2. Have successfully completed a formal training program in radiologic technology that is approved by the Council on Allied Health Education and Accreditation; or

3. Have had at least five years' experience in performing radiologic procedures and at least one year's experience in performing mammography before October 1, 1992.

(2) Each general radiographer must have completed successfully 40 hours of specialized training, approved by the agency, to include a minimum of one hour of hands-on mammographic positioning, quality control, technique factor settings and other areas pertinent to mammography prior to the time the individual begins performing mammography and an average of five hours of specialized training every 12 months thereafter to be averaged over no more than a 36-month period.

Training programs shall be submitted to the agency for approval and shall include demonstrations and practical evaluation by the instructor of the student's performance and documentation describing training, date and length of training, and evaluation of student's performance to be signed and dated by the instructor, and the business address of the supplier of the training.

e. Personnel orientation. The supplier of mammography services must have an orientation program for operators of mammography equipment based on a procedures manual that is available to all staff members and that incorporates relevant documents and instructions concerning the following:

(1) Precautions to protect the operator of the equipment, the patient and individuals in the surrounding area from unnecessary exposure to radiation.

(2) Determination of the area that will receive the primary beam (breast positioning).

(3) Pertinent information on compression, exposure levels, resolution, contrast, noise, examination identification, artifacts, and average glandular dose per view.

(4) Employee responsibilities concerning the proper use of personal radiation monitors.

(5) Proper use and maintenance of equipment, including a discussion of the image receptors appropriate for use with mammography and the kV-target-filter combination to be used with each image receptor.

(6) Proper maintenance of records.

(7) Possible technical problems and solutions.

(8) Protection against electrical hazards.

(9) Hazards of excessive exposures to radiation.

(10) Quality control procedures and those individuals responsible for performing them.

f. Personnel records. Records must be maintained to indicate that each employee is qualified for a specific position by means of appropriate state or other certification, license, training, and experience.

41.6(4) *Obtaining and preserving records.*

a. The supplier of the current mammography examination must make all reasonable efforts to obtain the patient's recent mammography records, including original images or films, copies of written reports prepared by interpreting physicians, and other relevant information pertinent to previous mammograms that might be available from others, for comparison with the current mammography records.

b. The supplier must make, for each patient, a record of the mammography services it provides, including:

- (1) The date the mammography procedure was performed and the date of the interpretation.
- (2) The name of the patient.
- (3) The name of the operator of the equipment and the interpreting physician.
- (4) A description of the procedures performed.
- (5) The name of the referring physician (if any) or other physician (if any) identified by the patient to receive the interpreting physician's written report.
- (6) The date the interpreting physician's written report was sent to the appropriate physician or patient.

c. Preservation of records.

(1) The supplier must provide satisfactory assurances (as documented in its medical records) that the images or films of the first and subsequent mammography procedures and the related written reports of the interpreting physician for each patient are either placed in the patient's medical record kept by the supplier or sent for placement in the patient's medical record as directed by the patient's physician or the patient.

(2) Records retained by the supplier must be retained for at least 60 calendar months following the date of service or not less than ten years, if no additional mammograms of the patient are performed.

(3) If the supplier should cease to exist before the end of the 60-month period, the records must be transferred to the patient or patient's physician.

41.6(5) *Quality assurance program.*

a. The supplier shall ensure that the facility has an equipment quality assurance program specific to mammography and covering all components of the system, to ensure consistently high-quality images with minimum patient exposure.

b. The supplier shall ensure that a general review of the program is conducted at least annually and have available the services of a qualified radiation physicist who is capable of establishing and conducting the program.

c. Under the direction of the physician consultant, the radiation physicist shall have responsibility for establishing and conducting the equipment quality assurance program. The program shall include:

- (1) Conducting or training others to conduct equipment performance monitoring functions.
- (2) Analyzing the monitoring results to determine if there are any problems requiring correction.
- (3) Ensuring that the facility has procedures in place for carrying out or arranging for the necessary corrective actions as well as for the calibrations and other preventive maintenance.

- d.* Calibration of equipment. All variable parameters of the equipment shall be calibrated:
- (1) When the equipment is first installed.
 - (2) After any major changes or replacement of parts.
 - (3) At least annually during use based on recommendations of the mammography imaging medical physicist.
 - (4) When quality assurance tests indicate that calibration is needed.
- e.* Performance monitoring. The supplier shall routinely ensure that the performance of the mammography system is monitored. The parameters to be monitored shall include but not be limited to:
- (1) Processor performance (through daily sensitometric-densitometric means).
 - (2) Half-value layer.
 - (3) Output reproducibility and linearity.
 - (4) Automatic exposure control reproducibility and linearity.
 - (5) Adequacy of film storage (both before use and after exposure if processing does not occur immediately).
 - (6) Availability and use of technique charts that shall include an indication of the kV-target-filter combination to be used with each image receptor.
 - (7) Darkroom integrity, to be performed at least semiannually or when conditions have changed, shall include an inspection for light leaks, a fog test, and a safe light test.
 - (8) Image quality. The minimum image quality achieved at a mammographic facility shall be the ability to observe the image of four 0.75-mm fibrils, three 0.32-mm specks, and three 0.75-mm masses from an ACR-approved phantom (or equivalent) on the standard mammographic film used at the facility. No mammograms shall be performed if this minimum is not met.
- f.* Frequency of monitoring.
- (1) Processor performance shall be accomplished daily before processing patient films.
 - (2) Image quality shall be monitored at least monthly with a phantom and every time the unit is altered including the replacement of parts.
 - (3) All other parameters shall be proportional to the expected variability of each parameter, but at least annually.
- g.* Evaluation of monitoring results.
- (1) Standards of image quality giving acceptable ranges of values for each of the parameters tested shall be established to aid in the evaluation. The standards of image quality related to dose shall include a requirement that the mean glandular dose for one craniocaudal view of a 4.5 cm compressed breast (50 percent adipose/50 percent glandular) or equivalent phantom shall not exceed 100 mrad (millirad) for film/screen units with no grids, or 300 mrad for film/screen units with grids.
 - (2) The monitoring results shall be compared routinely to the standards of image quality in Appendix I. If the results fall outside the acceptable range, the test shall be repeated. If the results continue to be unacceptable, the source of the problem shall be identified and corrected before further examinations are conducted.
- h.* Retake analysis program.
- (1) A program shall be established as a further aid in detecting and correcting problems affecting image quality or exposure.
 - (2) All retakes shall be logged including date, technologist's name and reason for retake. A retake analysis shall be performed every 250 patients or quarterly, whichever comes first.
- i.* Medical outcomes audit. Each facility shall establish a system for reviewing outcome data from all mammography performed, including follow-up on the disposition of positive mammograms and correlation of surgical biopsy results with mammogram reports.
- j.* Responsibility for each requirement for monitoring shall be assigned to qualified personnel and documented in the supplier's records.

41.6(6) Equipment standards. The equipment used to perform mammography shall meet the following standards:

- a. Be specifically designed for mammography.
- b. Meet the Food and Drug Administration (FDA) performance standards for diagnostic X-ray systems and their major components found in 21 CFR 1020.30 and FDA standards for radiographic equipment in 21 CFR 1020.31.
- c. Have image receptor systems and individual components which are appropriate for mammography and used according to the manufacturer's recommendations.
- d. Have beam limitation which limits the useful beam so that the X-ray field at the plane of the image receptor does not extend beyond any edge of the image receptor at any designated source to image receptor distance (SID). However, the X-ray field may extend beyond the edge of the image receptor which is adjacent to the chest wall provided it does not extend beyond this edge by more than 2 percent of the SID.
- e. Check film/screen contact when cassettes are first placed into use and semiannually thereafter.
- f. Have limits to provide kV-target-filter combinations appropriate for the image receptors which have met the requirements of 41.6(6) "c."
- g. The focal spot size, magnification factor and source to image receptor distance (SID) are appropriate for mammography and in the ranges shown below:

SID	Nominal Focal Spot Size
>65 cm	< or = to 0.6 mm
50 to 65 cm	< or = to 0.5 mm
< or = to 50 cm	< or = to 0.4 mm

- h. Devices parallel to the imaging plane shall be available to immobilize and compress the breast with a force of at least 25 pounds per square inch and shall be capable of maintaining this compression for at least three seconds.
- i. Shall have the capability for using antiscatter grids.
- j. Shall have the capability of automatic exposure control.
- k. Shall have a control panel that:
 - (1) Gives a positive indication when X-rays are being produced.
 - (2) Gives an audible signal indicating termination of exposure.
 - (3) Includes labeled control settings or appropriate indications that show the physical factors used for exposure such as kilovoltage potential (kVp), milliamperere seconds (mAs), exposure time, and whether exposure termination is automatic.
- l. Shall indicate, or provide a means of determining, the mAs resulting from each exposure made with automatic exposure control.
- m. The viewbox shall be checked periodically to ensure optimal conditions. When the mammo-gram is placed on the viewbox, the area surrounding the film must be masked to exclude extraneous light which may reduce image contrast.
- n. Mobile units and vans.
 - (1) A phantom image shall be made and processed after each relocation.
 - (2) If processing is not available, a check of the radiation output shall be made.
 - (3) Equipment shall be recalibrated as necessary to maintain quality of phantom image.

41.6(7) Safety standards for mammography equipment.

- a. Proper safety precautions shall be maintained and shall include, but not be limited to, adequate shielding for patients, personnel, and facilities. The equipment shall be operated only from a shielded position.
- b. Equipment operators shall wear personnel monitors to measure their radiation exposure.
- c. Annual inspections shall be conducted by an inspector from the agency to ensure compliance with these rules. Identified hazards shall be promptly corrected.
- d. Equipment shall be shockproof and grounded to protect against electrical hazards.
- e. Records of all inspections, reports, and consultations shall be maintained for at least seven years.

RULE 41.6(136C)—APPENDIX I

Normally, the frequency of monitoring for each of the following should be no longer than the values given on the following table. The standards of image quality are also given on the table. The surveyor is expected to measure phantom image quality and calculate dose from a measured exposure to confirm that the guidelines meet the desired standards of image quality. The surveyor will determine if the other standards are met by checking the supplier’s monitoring records.

<u>ITEMS</u>	<u>FREQUENCY</u>	<u>STDS OF IMAGE QUALITY</u>
Processor	Daily	Mid-density step and density difference (contrast) < ± 0.1 OD of the optimized operating level and base + fog deviation ≤ 0.03 OD
HVL	Annually	Meas. HVL with compression device in field ≥ (kVp/100) mm Al and ≤ (kVp/100 + 0.1 mm Al)
Output reproducibility	*Quarterly	Coefficient of variation ≤ 0.05 with 4 exposures at the same technique
Output linearity	*Quarterly	mR/mAs values at any two consecutive tube current settings should not vary more than 0.1 times their sum.
Automatic exposure control reproducibility	Annually	The phantom used for measurements related to this and the two following automatic control parameters should be either acrylic or BR-12 and consist of at least three 2-cm-thick slabs to provide thicknesses of 2cm, 4cm, and 6cm (each having linear dimensions of at least 8 × 10 cm). When a fixed kVp is used to produce four images of the 4-cm-thick phantom, the maximum value for the coefficient of variation for exposure at the center of the image should be ≤ 0.05.
kVp response of automatic exposure	Annually	Film density maintained to ± 0.3 OD of the average optical density at the center of an exposure control phantom image over the range of kVp used in the facility. To obtain the average, at least four phantom images should be made, one each with the highest and lowest kVps commonly used in the facility and the other two at intermediate values.

<u>ITEMS</u>	<u>FREQUENCY</u>	<u>STDS OF IMAGE QUALITY</u>
Thickness response of automatic exposure control	Annually	Film density maintained to ± 0.3 OD of the average optical density at the center of a phantom image at each kVp commonly used in the facility. To obtain the average, images with phantom thickness of at least 2 cm, 4 cm, and 6 cm should be used.
Adequacy of unexposed film storage	Quarterly	Increase in base + fog density over storage time maintained to < 0.02 OD
Availability and use of technique charts	Monthly	Ensure that charts are available and used
kVp/target/filter combination	Daily	Must be unchanged from that indicated on the technique charts
Darkroom integrity	Clean Daily Fog measured when bulbs or filter changed and semiannually	Minimum dust particles on film. Fog not greater than 0.05 OD with 2-minute test
Phantom image quality	At least monthly	Phantom image scores not less than required ACR MAP (currently specified only using RMI phantoms) and that should not decrease more than one in any category between consecutive tests. Also, they should not have decreased by more than one in any category from the initial baseline phantom image.
Dose	Annually	See Appendix II

*If the supplier can document that the item has remained within limits for at least three consecutive monitoring periods, it may use a longer monitoring interval for any parameters except processor performance and phantom image quality. The period should not be longer than one year in any case. If during the longer monitoring interval the test results fall outside the "Standards of Image Quality" criteria, then the test frequency must revert to the original intervals for at least three consecutive quarters.

RULE 41.6(136C)—APPENDIX II
Glandular Dose (in mrad) for 1 Roentgen Entrance Exposure
4.5-cm Breast Thickness—50% Adipose/50% Glandular Breast Tissue*

Mo/Mo Target Filter X-Ray Voltage (kVp)													W/AI Target Filter Combination
HVL	23	24	25	26	27	28	29	30	31	32	33		
0.23	109												
0.24	113	116											
0.25	117	120	122										
0.26	121	124	126	128									
0.27	126	128	130	132	134								
0.28	130	132	134	136	138	139							
0.29	135	137	139	141	142	143	144						
0.30	139	141	143	145	146	147	148	149					170
0.31	144	146	147	149	150	151	152	153	154				175
0.32	148	150	151	153	154	155	156	158	159	160	160		180
0.33	153	154	155	157	158	159	160	162	163	164	164		185
0.34	157	159	160	161	162	163	164	166	167	168	168		190
0.35		163	164	166	167	168	169	170	171	172	172		194
0.36			168	170	171	172	173	174	175	176	176		199
0.37				174	175	176	177	178	178	179	180		204
0.38					179	180	181	182	182	183	184		208
0.39						184	185	186	186	187	188		213
0.40							189	190	191	192	192		217
0.41								194	195	196	196		221
0.42										200	200		225
0.43											204		230
0.44													234
0.45													238

To convert from entrance exposure in air in Roentgen to mean glandular breast dose in millirads, multiply the entrance exposure by the factor shown in the table for the appropriate kVp and beam quality (HVL) combination. For example, a measured entrance exposure of 0.50 Roentgen from a Mo/Mo Target Filter system at 30 kVp with a measured HVL of 0.36-mm aluminum yields an average glandular dose of $(0.50 \text{ R}) \times (174 \text{ mrad/R}) = 87 \text{ mrad}$ or 0.87 mGy.

*Wu X. Breast dosimetry in screen-film mammography. In: Barnes GT, Frey GD (eds), Screen film mammography: Imaging considerations and medical physics responsibilities. Madison, WI: Medical Physics Publishing; 159-175, 1991. W/AI conversion factors are derived from fits to data from Stanton L et al. Dosage evaluation in mammography. Radiology 1984; 150:577-584.

641—41.7(136C) X-ray machines used for mammographically guided breast biopsy.

41.7(1) Definitions. In addition to the definitions provided in rule 41.1(136C), the following definitions are applicable to this rule.

“Collaborative setting” means a setting in which a qualified radiologist and surgeon (under 41.7(3)“a” or 41.7(3)“c”) are working together in consultation and in performing mammographically guided breast biopsies with a common goal of the patient’s benefit.

“Mammographically guided breast biopsy” means a breast biopsy procedure performed with the utilization of a dedicated system which emits ionizing radiation and is designed specifically for that procedure.

“Supervising physician” means the physician designated by the facility/owner to:

1. Evaluate the equipment, personnel, procedures, and records annually; and
2. Establish and conduct the quality assurance program.

41.7(2) Registration and application standards and requirements.

a. Each radiation machine used to perform mammographically guided breast biopsies shall be registered according to 641—subrule 39.3(2).

b. Each facility wishing to perform mammographically guided breast biopsies shall apply to the agency for authorization by providing or verifying the following information for each machine:

(1) The mammographically guided breast biopsy equipment and facility meet the general requirements of these rules for radiation machines.

(2) The radiation machine is specifically designed to perform mammographically guided breast biopsies.

(3) The radiation machine is used according to these rules on patient radiation exposure and radiation dose levels.

(4) The radiation machine is operated by individuals meeting the requirements of this rule.

(5) The entire mammographically guided breast biopsy system is evaluated annually by a radiation physicist who meets the requirements of this rule.

(6) The equipment, personnel, procedures and records are evaluated annually by the supervising physician.

c. Withdrawal or denial of authorization.

(1) Authorization may be withdrawn with cause if any machine does not meet one or more of the standards of these rules.

(2) The facility shall have an opportunity for a hearing in connection with a denial or withdrawal of authorization.

(3) An emergency order withdrawing authorization may be issued if the agency finds the radiation machine or facility violates rules that seriously affect the health, safety and welfare of the public. An opportunity for hearing shall be held within five working days after the issuance of the order. The order shall be effective during the proceedings.

(4) If authorization is withdrawn, the radiation machine shall not be used until reinstated.

d. Reinstatement of authorization.

(1) An application for reinstatement shall be submitted and processed the same as an initial application.

(2) The agency shall inspect the radiation machine within 60 days of the approved reinstatement application.

(3) A certificate of reinstatement shall be issued only after the agency has inspected the radiation machine and facility and determined that they meet the requirements of these rules.

e. Inspections. The agency shall conduct an inspection of each radiation machine no later than 60 days after initial authorization and at least annually thereafter.

41.7(3) Physicians. Physicians must be qualified according to the setting and their role in performing mammographically guided breast biopsies as outlined below.

a. Requirements for a radiologist in a collaborative setting are as follows:

- (1) Initial training and qualifications.
 1. Must be qualified according to 41.6(3)“*b.*”
 2. Shall have performed at least 12 mammographically guided breast biopsies prior to July 1, 1998, or at least 3 hands-on image-guided breast biopsies under a physician who is qualified under 41.6(3)“*b.*” and has performed at least 24 mammographically guided breast biopsies.
 3. Shall have at least three hours of Category 1 CME in image-guided breast biopsy.
 4. Shall be responsible for mammographic interpretation, be experienced as noted in “2” above and be experienced in recommendations for biopsy and lesion identification at time of biopsy.
 5. Shall be responsible for oversight of all quality control and quality assurance activities.
 6. Shall be responsible for the supervision of the radiologic technologist and the medical physicist.
- (2) Maintenance of proficiency and CME requirements.
 1. Perform at least 12 mammographically guided breast biopsies per year or requalify as specified above in 41.7(3)“*a.*”(1).
 2. Obtain at least three hours of Category 1 CME in mammographically guided breast biopsy every three years.

b. Requirements for a physician other than a qualified radiologist in a collaborative setting are as follows:

- (1) Initial training and qualifications.
 1. Must have at least three hours of Category 1 CME in mammographically guided breast biopsy which includes instruction on triangulation for lesion location.
 2. Must have performed at least 12 mammographically guided breast biopsies prior to the effective date of these rules, or at least 3 hands-on mammographically guided breast biopsy procedures under a physician who is both qualified to interpret mammography according to 41.6(3)“*b.*” and has performed at least 24 mammographically guided breast biopsies.
 3. Shall be responsible for postbiopsy management of the patient.
- (2) Maintenance of proficiency and CME requirements.
 1. Perform or participate in at least 12 mammographically guided breast biopsies per year or requalify by performing 3 supervised procedures.
 2. Obtain at least three hours of Category 1 CME in mammographically guided breast biopsy every three years.

c. Requirements for a radiologist performing mammographically guided breast biopsy independently are as follows:

- (1) Initial training and requirements.
 1. Must be qualified according to 41.6(3)“*b.*”
 2. Initially, must have at least three hours of Category 1 CME in mammographically guided breast biopsy.
 3. Initially, must obtain at least 15 hours of CME in breast imaging including benign and malignant breast diseases.
 4. Must have performed at least 12 mammographically guided breast biopsies prior to July 1, 1998, or at least 3 hands-on mammographically guided breast biopsy procedures under a physician who is both qualified according to 41.6(3)“*b.*” and has performed at least 24 mammographically guided breast biopsies.

5. Must be responsible for mammographic interpretation.
 6. Must be responsible for patient selection.
 7. Must be responsible for quality assurance activities including medical audit (tracking of number of biopsies done, cancers found, benign lesions, biopsies needing repeat, and complications).
 8. Must be responsible for the oversight of all quality control.
 9. Must be responsible for the supervision of the radiologic technologist and the medical physicist.
 10. Must be responsible for postbiopsy management of the patient which may include referral to a surgeon for a follow-up on certain lesions.
- (2) Maintenance of proficiency and CME requirements.
 1. Perform at least 12 mammographically guided breast biopsies per year or requalify by performing 3 supervised procedures.
 2. Obtain at least three hours of Category 1 CME in mammographically guided breast biopsy every three years which includes postbiopsy management of the patient.
 - d. Requirements for a physician other than a qualified radiologist (under 41.7(3) "c") performing mammographically guided breast biopsy independently are as follows:
 - (1) Initial training and requirements.
 1. Must have evaluated at least 480 mammograms per year in the prior two years in consultation with a physician who is qualified according to 41.6(3) "b."
 2. Initially, must have at least 15 hours of Category 1 CME in mammographically guided breast imaging and biopsy or three years' experience having performed at least 36 image-guided breast biopsies.
 3. Must have four hours of Category 1 CME in medical radiation physics.
 4. Must have performed at least 12 mammographically guided breast biopsies prior to the effective date of these rules, or at least 3 hands-on mammographically guided breast biopsy procedures under a physician who is both qualified according to 41.6(3) "b" and has performed at least 24 image-guided breast biopsies.
 5. Must be responsible for patient selection.
 6. Must be responsible for quality assurance activities including medical audit (tracking of number of biopsies, cancers found, benign lesions, biopsies needing repeat and complications).
 7. Must be responsible for oversight of all quality control.
 8. Must be responsible for the supervision of the radiologic technologist and the medical physicist.
 9. Must be responsible for postbiopsy management of the patient.
- (2) Maintenance of proficiency and CME requirements.
 1. Continue to evaluate at least 480 mammograms per year in consultation with a physician who is qualified according to 41.6(3) "b."
 2. Perform at least 12 mammographically guided breast biopsies per year or requalify by performing 3 supervised procedures.
 3. Obtain at least three hours of Category 1 CME in mammographically guided breast biopsy every three years.

41.7(4) Medical physicist.

- a. Must be qualified according to 41.6(3)“c.”
- b. Must meet the following initial requirements:

- (1) Prior to July 1, 1998, have performed three hands-on mammographically guided breast biopsy physics surveys; or one hands-on mammographically guided breast biopsy physics survey under the guidance of a medical physicist qualified through 41.7(4)“a” and 41.7(4)“b.”

- (2) On or after July 1, 1998, have one hands-on image-guided breast biopsy physics survey under the guidance of a medical physicist qualified to perform mammographically guided breast biopsy physics surveys. Have at least one mammographically guided breast biopsy physics survey per year after the initial qualifications are met; and three hours of continuing education in mammographically guided breast biopsy physics every three years after the initial qualifications are met.

41.7(5) Radiologic technologist.

- a. Must be qualified according to 41.6(3)“d.”
- b. Must meet the following initial requirements:

- (1) Five hands-on procedures on patients under the supervision of a qualified physician or technologist.

- (2) Three hours of continuing education in mammographically guided breast biopsy.

- c. Thereafter, an average of at least 12 mammographically guided breast biopsies per year after initial qualifications are met.

- d. Three hours of continuing education in mammographically guided breast biopsy every 3 years after initial qualifications are met.

41.7(6) Obtaining and preserving records.

- a. The facility must make, for each procedure, a record of the service provided including:

- (1) The date of the procedure.
- (2) The name of the patient.
- (3) The name of the radiologic technologists and physicians performing the procedure.
- (4) A description of the service provided.
- (5) The name of the referring physician, if any.

- b. Records retained by the medical facility must be retained for at least ten years.

41.7(7) Quality assurance program.

- a. The facility shall have an equipment quality assurance program specific to image-guided breast biopsy systems and covering all components of the system to ensure high-quality images with minimum patient exposure.

- b. The facility shall ensure that a general review of the program is conducted at least annually and have available the services of a qualified radiation physicist who is capable of establishing and conducting the program.

- c. Under the direction of the supervising physician, the radiation physicist shall have the responsibility for establishing and conducting the equipment quality assurance program. The program shall include:

- (1) Conducting equipment performance monitoring functions, at least annually, to include:
 - 1. Evaluation of biopsy unit assembly.
 - 2. Evaluation of focal spot.
 - 3. kVp accuracy/reproducibility.
 - 4. Half-value layer measurement.
 - 5. Exposure reproducibility.

6. Breast entrance exposure, average glandular dose.
7. Image quality evaluation.
8. Artifact evaluation.
9. Digital field uniformity.
10. Localization simulation (gelatin phantom) test.
11. Evaluation of the facility's technologist quality control program.
- (2) Analyzing the monitoring results to determine if there are any problems requiring correction.
- (3) Ensuring that the facility has procedures in place for carrying out or arranging for the necessary corrective actions as well as for the calibrations and other preventative maintenance.

d. The supervising physician shall have the responsibility for establishing and conducting the quality control program in a facility with a fixed unit. In the case of a mobile stereotactic unit, the owner or designee shall assume the responsibility for establishing and conducting the quality assurance program. The program shall include:

- (1) Localization accuracy (daily before use and before using the localization unit after it is adjusted).
- (2) Visual checklist (weekly).
- (3) Phantom image (weekly).
- (4) Compression (semiannually).
- (5) Processor sensitometry (daily before use with systems utilizing film).

e. Each facility shall establish a medical audit program to ensure the accuracy and appropriateness of the procedures performed. This program shall include an imaging-pathology correlation for each biopsy performed, an ongoing analysis of biopsy results and periodic review of the utilization of the procedure.

41.7(8) *Equipment standards.*

- a. Be specifically designed for mammographically guided breast biopsy.
- b. Meet the Food and Drug Administration (FDA) standards found in 21 CFR.

41.7(9) *Safety standards.*

- a. Proper safety precautions shall be maintained and shall include, but not be limited to, adequate shielding for patients, personnel and facilities. The equipment shall be operated only from a shielded position.
- b. Equipment operators shall wear personnel monitors to monitor their radiation exposure.
- c. Annual inspections shall be conducted by an inspector from the agency to ensure compliance with these rules. Identified hazards shall be promptly corrected.
- d. Equipment shall be shockproof and grounded to protect against electrical hazards.
- e. Records of all inspections, reports and consultations shall be maintained for at least seven years.

This rule is intended to implement Iowa Code chapter 136C.

CHAPTER 41—APPENDIX A

INFORMATION ON RADIATION SHIELDING
REQUIRED FOR PLAN REVIEWS (EXCLUDING THERAPY MACHINES)

In order for the agency to provide an evaluation, technical advice, and official approval on shielding requirements for a radiation installation, the following information shall be submitted.

1. The plans should show, as a minimum, the following:

(a) The normal location of the X-ray system's radiation port; the port's travel and traverse limits; general direction(s) of the useful beam; locations of any windows and doors; the location of the operator's booth; and the location of the X-ray control panel.

(b) The structural composition and thickness or lead equivalent of all walls, doors, partitions, floor, and ceiling of the room(s) concerned.

(c) The dimensions of the room(s) concerned.

(d) The type of occupancy of all adjacent areas inclusive of space above and below the room(s) concerned. If there is an exterior wall, show distance to the closest area(s) where it is likely that individuals may be present.

(e) The make and model of the X-ray equipment, the energy waveform (single phase, three phase, etc.) and the maximum technique factors.

(f) The type of examination(s) or treatment(s) which will be performed with the equipment.

2. Information on the anticipated workload of the X-ray system(s) in mA-minutes per week.

3. If the services of a qualified expert have been utilized to determine the shielding requirements, a report, including all basic assumptions used, shall be submitted with the plans.

CHAPTER 41—APPENDIX B

DESIGN REQUIREMENTS FOR AN
OPERATOR'S BOOTH1. Space requirements:

- (a) The operator shall be allotted not less than 7.5 square feet (0.697 m) of unobstructed floor space in the booth.
- (b) The operator's booth may be any geometric configuration with no dimension of less than 2 feet (0.61 m).
- (c) The space shall be allotted excluding any encumbrance by the X-ray control panel, such as overhang, cables, or other similar encroachments.
- (d) The booth shall be located or constructed such that unattenuated direct scatter radiation originating on the examination table or at the wall cassette will not reach the operator's station in the booth.

2. Structural requirements:

- (a) The booth walls shall be permanently fixed barriers of at least 7 feet (2.13 m) high.
- (b) When a door or movable panel is used as an integral part of the booth structure, it must have an interlock which will prevent an exposure when the door or panel is not closed.
- (c) Shielding shall be provided to meet the requirements of 641—Chapter 40.

3. X-ray control placement:

The X-ray control for the system shall be fixed within the booth; and

- (a) Shall be at least 40 inches (1.02 m) from any point subject to direct scatter, leakage or primary beam radiation.
- (b) Shall allow the operator to use the majority of the available viewing windows.

4. Viewing system requirements:

- (a) Each booth shall have at least one viewing device which will:
 - (1) Be so placed that the operator can view the patient during any exposure, and
 - (2) The device shall be so placed that the operator can have full view of any occupant of the room and should be so placed that the operator can view any entry into the room. If any door which allows access to the room cannot be seen from the booth, then outside that door there shall be an "X-ray" warning sign that will be lighted anytime the rotor of the X-ray tube is activated. Alternatively, that door must have an interlock controlling the exposure which will prevent the exposure if the door is not closed.
- (b) When the viewing system is a window, the following requirements also apply:
 - (1) The viewing area shall be at least 1 square foot (0.0929 m²).
 - (2) Regardless of size or shape, at least 0.09 m² (1 sq ft) of window area must be centered no less than 0.6 m (2 feet) from the open edge of the booth and no less than 1.5 m (5.0 feet) from the floor.
 - (3) The material constituting the window shall have the same lead equivalence as that required in the booth's wall in which it is mounted.
- (c) When the viewing system is by mirrors, the mirror(s) shall be so located as to accomplish the general requirements of Appendix B, 4(a).
- (d) When the viewing system is by electronic means:
 - (1) The camera shall be so located as to accomplish the general requirements of Appendix B, 4(a), and
 - (2) There shall be an alternate viewing system as a backup for the primary system.

CHAPTER 41—APPENDIX C

INFORMATION TO BE SUBMITTED BY PERSONS
PROPOSING TO CONDUCT HEALING
ARTS SCREENING

Persons requesting that the agency approve a healing arts screening program shall submit the following information and evaluation:

1. Name and address of the applicant and, where applicable, the names and addresses of agents within this state.
2. Diseases or conditions for which the X-ray examinations are to be used in diagnoses.
3. A detailed description of the X-ray examinations proposed in the screening program.
4. Description of the population to be examined in the screening program, i.e., age, sex, physical condition, and other appropriate information.
5. An evaluation of any known alternate methods not involving ionizing radiation which could achieve the goals of the screening program and why these methods are not used instead of the X-ray examinations.
6. An evaluation by a qualified expert of the X-ray system(s) to be used in the screening program. The evaluation by the qualified expert shall show that such system(s) does satisfy all requirements of these regulations. The evaluation shall include a measurement of patient exposures from the X-ray examinations to be performed.
7. A description of the diagnostic film quality control program.
8. A copy of the technique chart for the X-ray examination procedures to be used.
9. The qualifications of each individual who will be operating the X-ray system(s).
10. The qualifications of the individual who will be supervising the operators of the X-ray system(s). The extent of supervision and the method of work performance evaluation shall be specified.
11. The name and address of the individual who will interpret the radiograph(s).
12. A description of the procedures to be used in advising the individuals screened and their private practitioners of the healing arts of the results of the screening procedure and any further medical needs indicated.
13. A description of the procedures for the retention or disposition of the radiographs and other records pertaining to the X-ray examinations.
14. An indication of the frequency of screening and the duration of the entire screening program.

APPENDIX D **QA for Therapeutic Radiation Machines**

Frequency	Procedure	Tolerance^a
Daily	<u>Dosimetry</u>	
	X-ray output constancy	3%
	Electron output constancy ^b	3%
	<u>Mechanical</u>	
	Localizing lasers	2mm
	Distance indicator (ODI)	2mm
	<u>Safety</u>	
	Door interlocks	functional
	Audiovisual monitors	functional
Monthly	<u>Dosimetry</u>	
	X-ray output constancy ^c	2%
	Electron output constancy ^c	2%
	Backup monitor constancy	2%
	X-ray central axis dosimetry parameter (PDD, TAR) constancy	2%
	Electron central axis dosimetry parameter constancy (PDD)	2mm @ therapeutic depth
	X-ray beam flatness constancy	2%
	Electron beam flatness constancy	3%
	X-ray and electron symmetry	3%
	<u>Safety Interlocks</u>	
	Wedge, electron cone interlocks	functional
	<u>Mechanical</u>	
	Light/radiation field coincidence	2mm or 1% on a side ^d
	Gantry/collimator angle indicators	1 degree
	Wedge position	2mm (or 2% change in transmission factor)
	Tray position	2mm
	Applicator position	2mm
	Field size indicators	2mm
	Cross-hair centering	2mm diameter
	Treatment couch position indicators	2mm/1deg
	Latching of wedges, blocking tray	functional
	Jaw symmetry ^e	2mm
	Field Light intensity	functional

^a The tolerances listed in the tables should be interpreted to mean that if a parameter either: (1) exceeds the tabulated value (e.g., the measured isocenter under the gantry exceeds 2 mm diameter); or (2) that the change in the parameter exceeds the nominal value (e.g., the output changes by more than 2%), then an action is required. The distinction is emphasized by the use of the term constancy for the latter case. Moreover, for constancy, percent values \pm the deviation of the parameter with respect to its nominal value; distances are referenced to the isocenter or nominal SSD.

^b All electron energies need not be checked daily, but all electron energies are to be checked at least twice weekly.

^c A constancy check with a field instrument using temperature pressure corrections.

^d Whichever is greater. Should also be checked after change of light field source.

^e Jaw symmetry is defined as the difference in distance of each jaw from the isocenter.

Frequency	Procedure	Tolerance ^a
Annual	<u>Dosimetry</u>	
	X-ray/electron output calibration constancy	2%
	Field size dependence of X-ray output constancy	2%
	Output factor constancy for electron applicators	2%
	Central axis parameter constancy (PDD, TAR)	2%
	Off-axis factor constancy	2%
	Transmission factor constancy for all treatment accessories	2%
	Wedge transmission factor constancy ^f	2%
	Monitor chamber linearity	1%
	X-ray output constancy vs. gantry angle	2%
	Electron output constancy vs. gantry angle	2%
	Off-axis factor constancy vs. gantry angle	2%
	Arc mode	Mfrs. specs.
	<u>Safety Interlocks</u>	
	Follow manufacturer's test procedures	functional
	<u>Mechanical</u>	
	Collimator rotation isocenter	2mm diameter
	Gantry rotation isocenter	2mm diameter
	Couch rotation isocenter	2mm diameter
	Coincidence of collimetry, gantry, couch axes with isocenter	2mm diameter
	Coincidence of radiation and mechanical isocenter	2mm diameter

^a The tolerances listed in the tables should be interpreted to mean that if a parameter either: (1) exceeds the tabulated value (e.g., the measured isocenter under the gantry exceeds 2 mm diameter); or (2) that the change in the parameter exceeds the nominal value (e.g., the output changes by more than 2%), then an action is required. The distinction is emphasized by the use of the term constancy for the latter case. Moreover, for constancy, percent values \pm the deviation of the parameter with respect to its nominal value; distances are referenced to the isocenter or nominal SSD.

^f Most wedges' transmission factors are field size and depth dependent.

APPENDIX E
INFORMATION ON RADIATION SHIELDING REQUIRED
FOR PLAN REVIEWS FOR THERAPY MACHINES

I. All therapeutic radiation machines.

A. Basic facility information including: name, telephone number and agency registration number of the individual responsible for preparation of the shielding plan; name and telephone number of the facility supervisor; and the street address (including room number if applicable) of the external beam radiation therapy facility. The plan should also indicate whether this is a new structure or a modification to existing structure(s).

B. All wall, floor, and ceiling areas struck by the useful beam shall have primary barriers.

C. Secondary barriers shall be provided in all wall, floor, and ceiling areas not having primary barriers.

II. Therapeutic machines up to 150 kV (photons only).

In addition to the requirements listed in Section I above, therapeutic radiation machine facilities which produce only photons with a maximum energy less than or equal to 150 kV shall submit shielding plans which contain, as a minimum, the following additional information:

A. Equipment specifications, including the manufacturer and model number of the therapeutic radiation machine, as well as the maximum technique factors.

B. Maximum design workload for the facility including total weekly radiation output (expressed in gray (rad) or air kerma at one meter), total beam-on time per day or week, the average treatment time per patient, along with the anticipated number of patients to be treated per day or week.

C. A facility blueprint/drawing indicating: scale (0.25 inch = 1 foot is typical); direction of north; normal location of the therapeutic radiation machine's radiation port(s); the port's travel and traverse limits; general direction(s) of the useful beam; locations of any windows and doors; and the location of the therapeutic radiation machine control panel. If the control panel is located inside the external beam radiation therapy treatment room, the location of the operator's booth shall be noted on the plan and the operator's station at the control panel shall be behind a protective barrier sufficient to ensure compliance with 641—40.15(136C).

D. The structural composition and thickness or lead/concrete equivalent of all walls, doors, partitions, floor, and ceiling of the room(s) concerned.

E. The type of occupancy of all adjacent areas inclusive of space above and below the room(s) concerned. If there is an exterior wall, show distance to the closest area(s) where it is likely that individuals may be present.

F. At least one example calculation which shows the methodology used to determine the amount of shielding required for each physical condition (i.e., primary and secondary leakage barriers, restricted and unrestricted areas, entry door(s)) and shielding material in the facility.

(1) If commercial software is used to generate shielding requirements, identify the software used and the version/revision date.

(2) If the software used to generate shielding requirements is not in the open literature, submit quality control sample calculations to verify the result obtained with the software.

III. Therapeutic radiation machines over 150 kV.

In addition to the requirements listed in Section I above, therapeutic radiation machine facilities which produce photons or electrons with a maximum energy in excess of 150 kV or electrons shall submit shielding plans which contain, as a minimum, the following additional information:

A. Equipment specifications including the manufacturer and model number of the therapeutic radiation machine, and gray (rad) at the isocenter and the energy(s) and type(s) of radiation produced (i.e., photon, electron). The target to isocenter distance shall be specified.

B. Maximum design workload for the facility including total weekly radiation output (expressed in gray (rad) at one meter), total beam-on time per day or week, the average treatment time per patient, along with the anticipated number of patients to be treated per day or week.

C. Facility blueprint/drawing (including both floor plan and elevation views) indicating relative orientation of the therapeutic radiation machine, scale (0.25 inch = 1 foot is typical), type(s), thickness and minimum density of shielding material(s), direction of north, the locations and size of all penetrations through each shielding barrier (ceiling, walls and floor), as well as details of the door(s) and maze.

D. The structural composition and thickness or concrete equivalent of all walls, doors, partitions, floor, and ceiling of the room(s) concerned.

E. The type of occupancy of all adjacent areas inclusive of space above and below the room(s) concerned. If there is an exterior wall, show distance to the closest area(s) where it is likely that individuals may be present.

F. Description of all assumptions that were in shielding calculations including, but not limited to, design energy (i.e., room may be designed for 6 MV unit although only a 4 MV unit is currently proposed), workload, presence of integral beam-stop in unit, occupancy and use(s) of adjacent areas, fraction of time that useful beam will intercept each permanent barrier (walls, floor and ceiling) and "allowed" radiation exposure in both restricted and unrestricted areas.

G. At least one example calculation which shows the methodology used to determine the amount of shielding required for each physical condition (i.e., primary and secondary leakage barriers, restricted and unrestricted areas, small angle scatter, entry door(s) and maze) and shielding material in the facility.

(1) If commercial software is used to generate shielding requirements, also identify the software used and the version/revision date.

(2) If the software used to generate shielding requirements is not in the open literature, submit quality control sample calculations to verify the result obtained with the software.

IV. Neutron shielding.

In addition to the requirements listed in Section III above, therapeutic radiation machine facilities which are capable of operating above 10 MV shall submit shielding plans which contain, as a minimum, the following additional information:

A. The structural composition, thickness, minimum density and location of all neutron shielding material.

B. Description of all assumptions that were used in neutron shielding calculations including, but not limited to, neutron spectra as a function of energy, neutron fluency rate, absorbed dose and dose equivalent (due to neutrons) in both restricted and unrestricted areas.

C. At least one example calculation which shows the methodology used to determine the amount of neutron shielding required for each physical condition (i.e., restricted and unrestricted areas, entry door(s) and maze) and neutron shielding material utilized in the facility.

(1) If commercial software is used to generate shielding requirements, also identify the software used and the version/revision date.

(2) If the software used to generate shielding requirements is not in the open literature, submit quality control sample calculations to verify the result obtained with the software.

D. The method(s) and instrumentation which will be used to verify the adequacy of all neutron shielding installed in the facility.

V. References.

A. NCRP Report 49, "Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma Rays of Energies Up to 10 MeV" (1976).

B. NCRP Report 51, "Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities" (1977).

C. NCRP Report 79, "Neutron Contamination from Medical Electron Accelerator" (1984).

These rules are intended to implement Iowa Code chapter 136C.

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